WAGE INCENTIVE METHODS

THEIR SELECTION, INSTALLATION AND OPERATION

By

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PREFACE

The complete change in labor conditions since the first edition of this book was published, the tempo of our nation's greatest wartime industrial effort, only emphasize the vital importance of wage incentives in production today. They have faced the double test of depression and intense activity. Those events have affected incentive plans in numerous ways, but have not lessened either the extent or effectiveness of their use. Unwise complexities have been eliminated, procedures have been refined and some applications restricted, but in general incentives are being accepted more widely than ever as essential to high productivity and low total cost.

As a time-honored means to these ends wage incentives had achieved considerable maturity by 1929, when the first edition of this book was published; but the principles and techniques which can now be presented amount virtually to a science. This scientific ripening is timely in that it can be used at once by executives to intensify urgently needed time-cost economies and simultaneously to provide the means of meeting the ever-increasing demands of labor.

In this revision important improvements have been made. In the first place the new book is better arranged. Job Evaluation, a wholly new solution to rate setting, comes first. For this first chapter over a hundred current contributions have been impartially digested into a selective treatment that will enable an executive to appraise the various developments which have lately been successful and to determine which of four methods is best suited to his needs. Chapter 2 reviews briefly some historical aspects, shows the extent to which financial incentives are now used, and ends with an explanation of union attitudes toward them. Chapter 3 deals with the problems an executive must face in selecting the best wage plan for any particular situation. Definite steps are given for such procedure. Chapter 4 sets up the methodology of analysis used to reach the conclusions given throughout the remainder of the book. This is naturally somewhat technical, but clean cut and eminently practical. It should be studied by those who must get down to final design of earning curves or adjustment of details, but may be omitted by chief executives who are interested in general characteristics primarily. The latter will do well, however, to assign this chapter to all assistants who are directly

concerned with incentive problems. Chapter 5 classifies the plans and so portrays the wide possibilities now available. Chapters 6 to 15 describe the various plans in the order of classification, showing earning and cost curves with data for over two dozen specific plans, general descriptions of other modifications, examples from practice and similar information to make available the lessons of experience.

As in the original book the treatment of various plans is standardized to make them all comparable at sight. This has made it possible for the author to point out all strong and weak characteristics. Such criticism has been done with impartiality. To the large number of charts and tables formerly presented have now been added some sixty new ones as well as further cases from practice. These aids to comparative study contributed much to the acceptance of the earlier book. This feature remains unchanged except that several plans formerly included as a means of demonstrating bad practice have now been dropped to make room for more of the good practice in wider fields. Thus it is possible to find cases in the book which are closely similar to the user's own cases.

At the end of the detailed portrayal of plans is a chapter, 15, devoted to "Accelerating Premium" plans. These plans are entirely new and are published here for the first time. They have emerged in answer to the minimum wage requirement; that is, they may be designed to start payment at any minimum wage rate, curve upwards through any desired average response point of efficiency-earning and continue either below piece rate or increasingly above that—all in single curves. Thus we meet a new legal condition, an old requirement of mutuality and at the same time achieve an ideal remuneration for expert workers. The need for this type of plan is obvious and several such attempts at solutions have been made, mostly for supervisors, but the computation required for variable curves has heretofore been a deterrent in their use. The theoretical mathematics has now been ingeniously carried out by Mr. Hugo Hanser, and all details are here included in an Appendix. With general formulas available the points of efficiency-earning can be tabulated and used for any suitable standardized work. They should find a definite usefulness.

Other chapters follow on Group Application, Incentives Supplementary to Production, Incentives for Indirect Production, Incentives for Office Workers, Supervisors, and Executives, and finally one on Installation. Treatment of these subjects makes available a great variety of practice which is particularly important now because these "last frontiers" are being explored as never before for waste elimination, and the incentive plan as an automatic and impersonal arrangement offers the surest solution for many of these problems.

Naturally, statistics have been brought up to date, largely from National Industrial Conference Board Studies in Personnel Policies. Tabular and graphic examples, set up to illustrate the main plans in the original book, have purposely been left unchanged. While the assumed time rate of $.48 an hour is only half the average rate prevailing today in factories, it is still above the legal minimum and where the rates are close to $1.00 an hour, the 100% on the earnings scale may be interpreted as the money rate thus providing two specific applications, one for unskilled work and one for fairly skilled work, without any translation from book to application. For other cases the use of percentages makes it fairly easy to translate as originally intended.

Acknowledgments are due to Dr. W. J. Donald, Managing Director of National Electrical Manufacturers' Association; Dr. Alvin Dodd, President of American Management Association; Dr. Virgil Jordan, President of National Industrial Conference Board; and Mr. H. D. Shaw, Commissioner of National Metal Trades Association, all of whom have extended the resources of their organization publications. An Appendix lists the names of the industrial concerns which have furnished case material without which the book would lack its diversification of experience. There is special indebtedness to Mr. Hugo Hanser for permission to use his work, already described. Appreciation is also expressed to Messrs. J. C. Hoffman, G. H. Isaacson, V. Lazzaro, C. D. Maldari, and A. A. Rubin, who assisted in organizing material for the chapter on Job Evaluation. And lastly the author acknowledges his obligation to Dr. L. P. Alford for his constructive advice and cooperation.

CHARLES WALTER LYTLE.

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The wisest man I ever knew said once, "If people did no more than they had to do life would come to a standstill tomorrow." The bit over and above what we are obliged to perform counts most of all. Duty alone will never inspire that last, extra grind. Only devotion backed by self-respect can win it. And such devotion is elicited only by those leaders whose judgments are just, yet whose praise is willing, quick, and generous.

—PRINCESS ALEXANDRA KROPOTKIN.

CHAPTER 1

JOB EVALUATION

How to measure and relate output and wages on some fair basis has become an important function of management.—C. M. SCHWAB.

Rate Setting Is Major Function.—The purposes of modern rate setting are as follows:

1. To pay a uniform rate for all similar services in each locality.
2. To attract and keep desirable employees without paying excessive, or "above-market" amounts.
3. To fit rates to job requirements and avoid favoritism.
4. To give merit recognition through promotion and wage increases.

The achievement of these purposes has been difficult since 1915. First the upheaval of World War I, next the prolonged prosperity of the twenties, then the depression, and now the defense effort. Each of these has in turn upset the *status quo,* left us economically out of balance and intellectually bewildered. Market demands have altered production volumes from one extreme to the other. Labor supply has also touched both limits. The dollar has shrunk. Social legislation has accelerated. And last but not least, organized labor has become more powerful. Labor as a whole is now getting 68% of the total national income.

All of these forces, and more, affect base rates. The jobs themselves are more difficult to appraise and classify. Each large industry has hundreds of specialized jobs which are not exactly duplicated in other industries. In other words, the names of such jobs, although sometimes identical, do not mean that the jobs are identical. Jigs, tooling, special machines, motion studied methods, conveyor handling, etc., have brought new individuality to thousands of jobs. Certainly a rate quotation by itself from one plant is no longer a final answer to another plant. There may, of course, be a few jobs in each plant which have escaped these new influences. Where such "key jobs" can be found they are still useful for interplant comparison as to "prevailing" or "going" rates and are being used as bases for whole structures. In general, however, each large company must now work independently, comparing mainly on such matters

as policies, which are causes, and on turnover and efficiency, which are results. The newest source of check is through the employees themselves. That is, employers are voluntarily turning to their employees for opinions regarding rates. This is as it should be now that collective bargaining has become the law of the land. In brief, the rate problem has emerged as a major one. As such it must be approached rationally and studiously.

Economic Behavior of Rates.—Basically, wages are determined by the law of supply and demand. A shortage of a particular type of skill makes it possible for workers in that field to demand and get higher wages, and an oversupply of labor results in lower wages, unemployment, or both. In any one locality, however, wages paid for a certain skill will show some variation depending on the wage policies of each employer. In general, the most profitable firms will pay the highest wages and the marginal firms the lowest.

Natural minimum rates payable by any firm, that is, the lowest rates which are not directly affected by legal mandate, approximate the lowest rates current in the local labor market. Lower rates than these result in employee indifference, turnover, and inadequate supply. A company can pay higher than average rates if, through good management, its employees can and do work at above average efficiency. A firm earning an unusually good profit does not necessarily have to pay higher than average wage rates, but may choose to do so to assure an adequate labor market from which it can select the best workers. Accelerating consumer demand and consequent widening of profit margins induce business to expand and hire more labor which ultimately results in an undersupply of labor and an increase in wage rates. On the other hand, a slackening of consumer demand results in curtailment of operations and an oversupply of labor and ultimately in lower rates. Neither employers nor employees can for long resist a general price movement.[1]

Irregular workers, such as building craftsmen, should be paid hourly rates high enough so that their net yearly earnings are about the same as that of full-time workers. Conversely, factory carpenters, painters, etc., who have full-time employment can be paid rates comparable to other factory workers and lower than regular building craftsmen on irregular work.

Adjustment of Rates to Cost of Living.—During World War I many English and a few American companies began to use a cost of living index or "sliding scale" as a means of automatically readjusting wage rates. In England these plans were generally arranged

[1] For a review of wage theories, see *Theory of Wages,* by Paul H. Douglas, 1934.

between the employer's association of a whole industry and the trade union. In America they were initiated by owners of individual companies and the index was made to reflect the local changes. Until recently this practice did not get far in the United States because prices, 1923 to 1929, were practically stable and the need for such adjustment disappeared. By 1936, however, the government arbitration boards had come to use such indices considerably and the General Electric Company, among others, decided to make an arrangement which would be automatic. In fact, the regular publication of indices by the Bureau of Labor Statistics (22 cities), the National Industrial Conference Board (56 cities), the Massachusetts Department of Labor and Industries, and the Michigan Department of Labor and Industry now makes it relatively easy for many companies to make these adjustments if they care to do so.[2] There are two dangers in any such plan. Statisticians do not agree on how the index should be made up. Hence there may be lack of confidence that the index truly reflects the actual cost of living. Even when the index is generally approved there remains the dislike of sudden or frequent revisions downward. If the plan is to be used it should be carefully worked out, reasonable warning time allowed, and the principle completely "sold" to labor. Labor may not like it.[3]

EXAMPLES OF ADJUSTMENT OF WAGES TO COST OF LIVING. The General Electric Company plan applied to all hourly rated employees and those on salary up to and including $4,000 per year. United States Department of Labor indices were used. For each point change of the indices above 80, a 1% rate change became automatically effective. The actual change was made when the index passed the half point, that is, from 80.5 to 81.4 the rates became 101% of the original bases, from 82.5 to 83.4 the rates were 103%, etc. These adjustments were calculated weekly on the gross basic earnings. A minimum 10% was fixed as the top rate limit and the basic rates at the time of the agreement were fixed as the low rate limits. No commitments were made as to future changes beyond these limits. In the fall of 1941 the plan was discontinued.

The International Ladies Garment Worker's Union has put the following plan into some of its agreements for piece and time rate workers. Whenever the United States Department of Labor indices show a change equal to or exceeding 5%, the rates shall be changed by the same percentage but made effective one month after the publication of the indices.

[2] In August, 1941, the Canadian government agreed to make these adjustments in the pay of its 250,000 railroad workers and civil servants.

[3] See article by Solomon Barkin, Director of Research, T. W. U. of A. (C. I. O.), N. I. C. B. Studies in Personnel Policy No. 33.

A public utility company applies the same indices to all employees earning less than $250 a month but figured on amounts less than $125. The adjustments are made only twice a year, January and July, if the change exceeds 3 points relative to the ones last used. Employees within each wage classification receive the same adjustment which is calculated to the nearest one-half cent for hourly workers and to the nearest $.50 for salaried workers.

Base Rates.—The hourly rate established for the least valuable work in a community is called the *fundamental base rate.* This is set mainly by supply and demand and is less local than other rates because of the greater "fluidity" of unskilled workers. In general, however, the regional cost of living becomes the lower limit of this rate.[4] *Base rates* for all other jobs are the prevailing rates for fulfilment of the minimum requirements of each job class. These range through the various degrees of semiskilled and skilled work, some of which are in the nature of "key jobs," and may be compared as to their "going-rates." Base rates for job classes, or labor grades, which include no dependable key jobs must be independently evaluated or interpolated relative to the known base rates of classes which do include key jobs.

In order to facilitate shifting back and forth between hour rate jobs and piece rate jobs it has always been desirable to establish a *base hourly rate for each piece rate operation.* This base should be derived like that of any time rate job and should be used for the *time rate portion, if any, of the incentive plan.* The *rate per piece* may, however, be figured backwards from the *average total earning per hour,* say over the previous month. Where piece payment or other incentive plan is backed by a *time guarantee for management delays* only, the rate for that is often set at 80% of the worker's average earnings per hour during the previous four weeks. This is justified by the experience that incentive workers usually produce 10% to 30% more than nonincentive workers and at 80% of their accustomed earnings will be at par with the latter. Perhaps for this temporary use such an arbitrary arrangement is good enough, but even if it is equivalent to the derived rate, it is preferable to derive the guarantee, that is, use a reliable base. If this is done the rate per piece can be built above it. The guaranteed rate exists to protect the incentive worker against any lack of opportunity to continue on incentive work. If on the other hand a foreman wishes him to do a nonincentive job, temporarily as a favor to the management, the hourly rate for such work should equal the full average of the man's

[4] "Wage Determination for Work on Public Contracts," *Monthly Labor Review*, January, May, July, and December, 1938.

incentive earning. If such favors are regularly demanded a management may grant the worker an hourly rate slightly above his former average. This is called a *versatility rate,* that is, the man is paid extra because he is able and willing to work at various jobs on demand.[5]

As to the *hiring rate,* it is best practice to hire at the regular base rate. Some companies have tried to start at 80% of the base but since the evaluated base rate is worked out on minimum requirements, anything less than 100% of it is conspicuously unjust except for a learning period and puts the company at a disadvantage in the labor market. The use of low rates as a starting level for bonuses still survives where an employer thinks he can thereby magnify his bonus, but such motive is transparent and only results in contempt. It is no longer done by enlightened management.

Rates for Night Shift.—Extra differentials for night and Sunday shifts are usually matters for union negotiation and have sometimes been forced to high amounts. Without such necessity it is common to increase these rates by some percentage, 10-33, usually to the same degree for all jobs. A few companies prefer to keep the base rates the same for all shifts and add a bonus percentage for whatever time is out of the regular shift. Where the various shifts are permanent and the personnel rotated from one to the other it may be possible to maintain the same rates for all shifts, but where 8-hour shifts are used it is impossible to have shifts of equal desirability and some differential is usually necessary. Where 6-hour shifts are used no extra differentials are needed.

Apprenticeship Rates.—The original idea that an apprentice to a skilled trade should pay for the privilege of learning, rather than be paid for it, has all but disappeared. In the first place he is usually older when he starts than formerly and rarely now does he receive lodging with board. Furthermore, under modern conditions he can, from almost the start, be more productive despite the costs of instruction and other kinds of burden charged against him. Since 1938 the Fair Labor Standards Act has *fixed the lower limit of pay.*[6] "The Administrator . . . shall by regulation or by orders provide for (1) the employment of learners or apprentices, . . . under special certificates issued pursuant to regulations of the Administrator, at such wages lower than the minimum wage applicable under Section 6 and subject to such limitations as to time, number, proportion

[5] Versatility is sometimes included in merit rating as one of the five or six man-characteristics, the periodic rating of which determines the man's individual differential above his job base-rate.

[6] *Wage and Hour Manual,* issued annually to answer questions of interpretation.

and length of service as the Administrator shall prescribe," etc. Actually these bottom rates vary considerably according to location and kind of trade. Usually the length of the whole apprenticeship is divided into about eight periods and a rising scale of rates set up to change at the end of each period. On the four-year average these rates amount to a little more than half of the rates paid to fully skilled workers in the same trades. In fact, some companies set up the learners' rates in terms of per cent so that the apprentice will be automatically kept in adjustment to the skilled workers, and in line to achieve the regular base rate at the end of apprenticeship. There is, of course, an incentive problem involved, and the increments may not be equal throughout the periods. (See Chapter 17.)

Overtime Rates.—The practice of paying *time and a half* for overtime made common by the War Labor Board in 1917-1918[7] has now become mandatory through the Fair Labor Standards Act. Section 7 of the act specifies such payment "at a rate not less than one and one-half times the regular rate at which he (employee) is employed" for each hour of work in any work week in excess of 40 hours per week. The interpretation of the board is that any bonus which is in the nature of a production bonus or premium must be included in the base upon which an employee's regular rate is computed. *Gratuities* not in the nature of a contract right, such as Christmas "bonuses," may be excluded. Similarly, a *profit-sharing "bonus"* which is given at the discretion of an employer, that is, with no legal right of anticipation either expressed or implied, may be excluded. But if a bonus is promised at the end of the year contingent on performance, it must be included. As soon as the amount of such annual bonus may be calculated it should be apportioned over the hours covered by the period and overtime rates for each particular week corrected. Averaging of other compensation or hours over two or more weeks is not permitted for overtime calculations.[8] Payment of an *annual bonus* was until 1938 becoming increasingly common. If wage rates are at or above the market average these bonuses have a good effect on employee goodwill. If wage rates are below market, employees will consider these merely as overdue wages. In any case since 1938 the delayed nature of these arrangements has imposed great difficulties and is causing some companies to cancel them.

Informal Rate Setting No Longer Adequate.—Job standardization, that is, motion and time study, developed directly from the

[7] *American Economic Review,* Vol. XXIX, No. 4.
[8] Interpretive Bulletin No. 4.

works of Taylor and Gilbreth with the objective of determining the most expedient method of doing a job and establishing work standards as dependable bases for tasks. This "science of work," plus a narrower functionalization of duties and a more careful selection of high class workers, pointed the way towards our present-day job evaluation, but the latter did not develop immediately nor directly from industrial engineering. It came from the personnel executives who needed to collect job information as an aid to hiring and placement.[9] Thus the *"job analysis"* of 1909-1917 began job study, at the point where engineers had ended, with the objective of determining job characteristics in relation to man-qualifications necessary for operating according to standards and making a rate structure which would bring economic satisfaction in such operation to all concerned. World War I gave impetus to this personnel function.[10] In banks and insurance companies where there were large forces of stenographers, clerks, etc., it assumed the form of *"Salary Standardization."*[11] The use of job analysis to determine rates scientifically did not get so far in the factories during the 1920's because the tendency was toward incentive payment where base rates were then considered incidental. Organized labor had, however, long advocated "standard wages" and numerous states passed minimum wage laws. The N.I.R.A. of 1933-1935 put the latter on a federal scale and the National Labor Relations Act of 1935 intensified the activity of the unions. After the Supreme Court sustained that law in 1937 the two-year-old C.I.O. was able to increase its membership by large numbers of unskilled and semiskilled workers and exerted a power never before wielded by American employees. Wage rates for large groups were set by collective bargaining and pushed upward frequently. Hours came down and, in not a few cases, efficiency per man-hour fell off alarmingly. In short, bargaining became as unbalanced in favor of employees as it had ever been unbalanced in favor of employers. Better substantiation of employers' claims became the need of the hour.

At the same time, a rapidly improving mechanization plus a widening use of motion study had been changing job methods so radically and frequently that few jobs in one plant remained exactly like similarly titled jobs in any other plant. Employers could use only the relatively few key jobs for rate comparisons, and even these needed to be checked by personal inspection. Thus the "going rate" for any class of jobs in a community became less evident, and more undependable, as a basis for informal rate setting. This

[9] A. M. A. Office Executives Series No. 17, paper written by E. O. Griffenhagen.
[10] Nat. Assoc. of Corp. Schools, Convention Report, 1919.
[11] *Salary Standardization*, by H. A. Hopf, Society of Industrial Engineers, 1921.

meant that the management of each plant had to work out its rate structure almost independently of interplant comparisons.

The situation just described would have been sufficient reason for perfecting the step of job evaluation, but the sudden widespread interest it evoked resulted from the union development previously described. Feeling their increased power, the union leaders began, in 1937, to raise such questions as, "Why has job A been paying five cents an hour less than job B?" And sometimes they displayed more accurate knowledge of the jobs in question than management possessed! In such a predicament the management turned to the personnel department for data. Where the job analysis-classification-specification and evaluation had been well done, an answer could be given at once which would sustain any variance and forestall embarrassment. Sometimes there was qualitative data but little quantitative data. Very often there was neither. The few plants which had pioneered in systematic evaluation soon acquired renown among the less foresighted. Feverish emulation followed.

Job Control as a Whole.—That part of shop management which undertakes the control of jobs may be completely summarized into six divisions or separate functions as follows:[12]

I. INVENTION AND CONSTRUCTION includes the development, design, and production of equipment, jigs, tools, and auxiliaries. It is always a function of the engineering department and is performed mostly by the more technical mechanical and electrical engineers.

II. JOB STANDARDIZATION includes the development and standardization of all conditions and processes, culminating in the most expedient arrangements, motions, and times for utilizing the material results of item I in producing goods or services. It is always a function of the methods department and is performed by industrial engineers who originally made this extension from mechanical engineering.

III. JOB REVIEW—ANALYSIS, etc., includes the recording of job descriptions, systematic analysis, specification for and classification of the same in relation to employee minimum qualifications. It is usually a function of the personnel department but should be shared by industrial engineers and line executives.

IV. JOB EVALUATION includes a study of the relative worth of essential job characteristics, culminating in a standardization of base rates and the construction of a mutually satisfactory rate structure.

12 "Job Evaluation—A Phase of Job Control," by C. W. Lytle, *A.M.A. Personnel*, Vol. 16, No. 4.

As it is a continuation of III it is a function of the personnel department. The final results must, however, be authorized by line executives.

V. Merit Rating includes the keeping of individual employee records and the appraisal of the same through some standardized system as a basis of rewarding extra worth of time rate workers, sometimes all workers. It is always a function of the personnel department and is done by follow-up assistants and interviews. It should apply to all employees but is less vital for incentive workers since they rate themselves in part through their earnings.

VI. Incentives, including the establishment of extra-financial incentives suitable to each set of conditions and nonfinancial incentives as a support to morale, both aiming to elicit optimum effort-response to advance arrangements of reward. This might logically belong to the personnel department and the nonfinancial part usually does but the extra-financial part was developed by industrial engineers, is closely interrelated with task standards and last but not least is a bit too technical to be coveted by some personnel staffs. Hence it is almost always a function of the methods department; both design and operation of plan are carried out by industrial engineers. Under best management, however, both the head of personnel and the line executives involved should be consulted on all developments to insure consideration of the broader labor relations and public relations aspects.

It is beyond the scope of this book to treat functions I, II, and V but III and IV will be given the rest of this chapter and VI all the rest of the book. Function III and its subordinate divisions may now be more closely outlined.

III. Job Review—Analysis, Etc.

IIIA. Job Review is the collecting of tentative descriptions of a job, preferably after standardization, in terms of the characteristics which may affect the kind of person needed to fill it and conditions which may independently affect the rate of pay needed for filling it. These tentative descriptions are gathered through questionnaire forms and (or) through interviews recorded on suitable forms. They should be drawn from several of the best operatives and resulting claims checked by the safety man, maintenance man, inspector, and supervisor concerned. See Figure 1 for sample form.[13]

[13] *A. M. A. Personnel*, Vol. 15, No. 3, "A Case History in Salary and Wage Administration," by L. H. Burk, Chief Job Analyst, Atlantic Refining Co.

INTERVIEWER'S ROUGH NOTE SHEET

Job Title .... Other Titles .... Dept. & Location .... Normal Force ....

Empl. Name .... Immed. Supervisor .... Time on This Job; Company .... Elsewhere ....

Equip. Used .... Tools Used .... Materials Used ....

....

....

Work Rec'd From .... With What Instructions ....

Duties ....
(Use Other Side If Necessary) ....
....
....

Work Goes To .... Describe Checks, Inspections, Etc. ....

Contacts With Others ....

Hours: Regular, From ...... To ...... Sunday, From ...... To ...... Shift .... Hours Overtime Per Mo. ....

Comments on Work. Cond.: Atmos. .... Temperature .... Ventilation ....

Surroundings .... Activity .... Hazards ....

Illumination .... Other ....

Exercises Supervision. Normal Force .... Type(s) of Work ....

Equipment Respons. .... Material Respons. ....

Opinions on Starting Requirements:

Age—Min. .... Male .... Married ...... Height—Min. .... Wt.—Min. ....

Max. ... Female .... Single .... Max. .... Max. ......

Misc. Remarks:

Special Physical ....

Education: Gr. 1 2 3 4 5 6 7 8 High 1 2 3 4 College 1 2 3 4

Other Educ. ....

Experience: Necessary ...... Years of ....

Desirable ...... Years of ....

Special Knowledge or Ability ....

Time for New Emp. to Become Proficient ....

Promote From .... Promote To ....

Worker: Fluent.. Average.. Could Not Express Thoughts.. Interviewer

Bright .. Intelligent .. Aver. .. Dull ..

Satisfactory Interview? Date

Figure 1. Interviewer's Form

IIIB. Job "Analysis" is the critical analysis and selective synthesis of the data derived through job review, and recording of findings to show the kind and degree of duties, skills, exertions, responsibilities, conditions, etc., which belong to a specific job, all expressed as minimum man-qualifications. Resulting record is known as the standard job description-specification. (See IIID.)

IIIC. Job Classification is the sorting of standard job descriptions-specifications into a relatively small number of classes, each of which includes all jobs, and only those, which are identical or equivalent in essential characteristics, that is, in level of responsibility and degree of skill, etc. Subclasses may be necessary to accommodate variations in kind on each level.

PROCEDURE FOR CLASSIFICATION.[14]

1. Standardize a "classification outline" or schematic arrangement which will set up the broad occupational divisions, and under them the narrower occupational groups and the individual "classes" of jobs, arranged according to series of classes, coming within each occupational group.
2. Standardize the class specifications (or occupational specifications) each to show:
   - (a) The adopted class title to be applied to the class and to all jobs in the class.
   - (b) A job-class description of the duties common to all jobs of the class supported by typical examples as illustrating kinds of work falling within each general description, chosen from actual cases, to support and amplify these general statements of duties.
   - (c) An enumeration of qualifications required, which may be grouped into two parts—necessary qualifications and desirable additional qualifications.
   - (d) Notes regarding lines of promotion, preferably in the form of a schedule of positions considered next higher in rank, and positions considered next lower in rank.
   - (e) Notes regarding compensation if there is a compensation plan in effect.
   - (f) Any other facts, rulings, or memoranda that relate to the class and that have a bearing on administrative processes in personnel matters.

[14] *Base Rates for Manual Workers*, by Virgil M. Palmer, A. M. A. Production Series No. 36.

3. Standardize the "rules of administration," presenting clearly and in logical order the principles and methods by which the classification plan is to be devised, adopted, applied, and amended; by which new and changed positions are to find their places under the classification outline; by which specifications are to be constructed, employed, and perfected; and by which employment processes are to be controlled or related to this basic plan and its scheme of nomenclature.

TABLE 1. CLASSIFICATION SCHEME FOR GRADING POSITIONS

GRADES AND SUB-GRADES

Services	Sub-grades	Grades	Classes
Executive Service	A B C	1. *General Management:* Establishes general procedure, organizes and directs the enterprise as a whole; makes decisions of general scope; adjusts relations with investors, the public and the personnel. (President, Vice President, General Manager, etc.)	I. *Management* — Formulation and development of general procedure and courses of action or policies, involving original observations, analyses, the establishing of standards, etc.; the original planning, organizing and executing of operations.
Executive Service; *Staff or Advisory Service*	A B C D E	2. *Departmental and Associate Management:* Establishes, organizes and directs procedure of major departmental scope or of inter-departmental scope but specialized or limited as to function—administration of a major department or subdivision of the organization, original investigation or research, invention, composition of data for informational and advisory purposes in general or major departmental administration. (Managers of departments and principal subdivisions, higher executive and staff assistants or their equivalents.)	
Staff or Advisory Service; *Supervisory Service*	A B	3. *Major Supervision or Highly Technical Service:* Execution of intricate operating practice by delegating activities and giving general directions to others in diverse occupations, depending upon their knowledge and experience for the performance of the tasks involved; observation and judgment of high order, involving the application of standards and analyses of established character; or, directly performing activities of a highly technical character but essentially established by higher authority and experience; resourceful application of courses of action. (Intermediate subdivision chiefs, technical assistants, superintendents, foremen, etc.)	II. *Operating Practice* — Supervision of or the direct performance of activities essentially established by authority, instruction or direct experience.
Supervisory Service; *Routine Service*	A B	4. *Highly Skilled Service or Minor Supervision:* Service involving observation and judgment of high order with the application of standards and analyses of established character, and intricate, complicated or exacting details dictated by authority and long experience, subject to general supervision only—necessitating at least several years' experience in training; or supervision of others in work of less technical character but requiring some degree of skill.	
Routine Service		5. *Skilled Service:* Service with features as in the next higher grade but less intricate and exacting and subject to more supervision, necessitating experience of from one to two years in training; may include detailed direction of others in service of lower grade.	
Routine Service		6. *Semi-skilled Service:* Routine work of limited scope requiring only short periods of experience or training (several months: for its successful performance; may include detailed direction of others in service of lower grade.	
Routine Service		7. *Slightly Skilled Service:* Tasks of simple character requiring only simple observations and responses with little learning and experience for their successful performance—subject to close direction.	
Routine Service		8. *Primary Service:* Tasks and routine of very simple character such as may be performed by junior workers, workers in early apprenticeship or similar elementary training and workers in manual service of simplest character.	

RELATED EXPERIENCE	OCCUPATION	DESCRIPTION	NO. EMP.		SALARY RATES			AVERAGE LENGTH SERVICE
			M.	W.	Max.	Min.	Avg.	
		ACCOUNTING — COST						
3 to 5 Years	Cost Clerk E-4	Sr. Compile complete factory cost of assemblies or finished products, from specifications, bills of material, requisitions and time cards, without detailed supervision. Verify costs on new products. Compare standard cost with actual cost. May involve preparation of necessary cost data for control of operations. Requires practical knowledge of products, manufacturing processes and procedures.						
12 to 18 Months	C-3	Jr. Compile factory costs on parts and assemblies following definite prescribed instructions under close supervision. Other junior clerical work as may be assigned.						
5 Years and Over	Cost Estimator F-2	Sr. Compile estimates of cost on standard and special parts or products, as a basis for pricing purposes. Should have engineering knowledge and be able to interpret engineering layouts and data. Requires extensive knowledge of products, designs, manufacturing processes and procedures.						
1 to 3 Years	D-1	Jr. Compile cost estimates on standard parts and assemblies working from positive information.						

Figure 2. Job Descriptions
(A. M. A. Office Management Series No. 84)

NATURE AND CONDITIONS OF WORK **(Use $\boxed{X}$ to indicate; $\boxed{XX}$ to stress; or indicate percentage, e. g. $\boxed{15}$ %)**

Place	Activity	☐ Heavy	Instruction	Atmosphere	Hazards
☐ Outdoor	☐ Standing	☐ Emergency	☐ Written	☐ Natural	☐ Fire
☐ Indoor	☐ Sitting	☐ Set-ups	☐ Verbal	☐ Ventilated	☐ Electricity
☐ Platform	☐ Hauling	☐ Layouts	Illumination	☐ Excellent	☐ Hernia
☐ Overhead	☐ Climbing	☐ Templates	☐ Natural	☐ Good	☐ Eyes
☐ Underground	☐ Lifting	☐	☐ Artificial	☐ Fair	☐ Ears
☐ Scaffold	☐ Walking	Surroundings	☐ Excellent	☐ Poor	☐ Lungs
☐ Pit	☐	☐ Clean	☐ Good	☐ Draughty	☐ Violence
☐ Unlocalized	Operation	☐ Dirty	☐ Fair	☐ Noxious Gas	☐ Hands
Type	☐ Repetitive	☐ Greasy	☐ Poor	☐ Fumes, odors	
☐ Desk	☐ Varied	☐ Gangwork	☐ Glare	☐ Dust	
☐ Bench	☐ Automatic	☐ Crowded		☐ Very dry	
☐ Machine	☐ Semi-Automatic	☐ Orderly		☐ Humid	
☐ Counter	☐ Much activity	☐ Distractions		☐ Hot	

Remarks: ....

.... Regular working hours: from.....to.....Sunday from.....to.....Shift.....Hours overtime per month...

REQUIREMENTS **(Use X, XX, % or $\boxed{R}$—required; $\boxed{P}$—preferred)**

Age	Height	☐ Bonded	☐ Add and subtract	Personal qualities	Experience
☐ Max.	☐ Max.	☐ Color discrimination	☐ Multiply and divide	☐ Unemotional	Kind
☐ Min.	☐ Min.	Education—limits	☐ Fract. and decimals	☐ Deliberate	....
Sex	Weight	Gr. 0 1 2 3 4 5 6 7 8	☐ Percentage	☐ Quick	....
☐ Male	☐ Max.	High 1 2 3 4	☐ Shop arithmetic	☐ Dynamic	....
☐ Female	☐ Min.	Coll. 1 2 3 4	☐ Read blue prints		....
Marital state	Intelligence (fifth)	Kind:—	☐ Good handwriting	☐ Tact	....
☐ Single	☐ Highest	....	English		....
☐ Married	☐ Second	....	☐ Understand	☐ Patience	☐ Journeyman
Color	☐ Average	....	☐ Speak		☐ Apprentice
☐ White	☐ Low	☐ Contact with ... people	☐ Read	☐ Fluency in conversation	☐ Inexperienced
☐ Black	☐ Lowest		☐ Write		

Special knowledge or experience..

Remarks: ....

Date.. Name of Interviewer ....

Figure 3. Job Description—Specification Check List

The standardized classes may be given symbols such as *A, B, C,* etc., and the subclasses shown as A_2, B_2, C_2, etc. Another method of symbolizing is to make numbers represent all the levels and letters represent the functional nature within a level. This is illustrated by Table 1 and the following example:[15]

Boiler Engineer.......	4A	Stoker Operator........	6
Water Tender........	4B	Boiler Cleaner..........	6
Pumpman...........	5	Ashman...............	7

but for most applications the eight levels would need to be expanded, or accommodated by additional subdivisions.

IIID. Job—Class Description-Specification is a composite of all the standard job descriptions within one class or subclass, omitting any variations within. It is invaluable as an aid to hiring, transferring, and promoting. There are three different kinds of description-specification which are used:

1. The essay, which is primarily a descriptive statement. Mostly used for salaried employees (Figure 2).
2. The standard form which is characterized by a list of items to be checked but with little or no space for the description of the job or its requirements (Figure 3).
3. The combination of the standard form with complete descriptive statements about different aspects of the job. Various combinations of the essay and of the standard forms have been developed (Figures 6, 7a, and 7b).

IV. Job Evaluation

Job evaluation is the ranking, grading and (or) weighting of essential work characteristics of all jobs or job-classes in some systematic way to ascertain the labor worth of each job or job-class relative to all others. Scientific evaluation is possible only when all of the foregoing steps I to IIID of job control have been standardized and carried out with unified control as the objective. The example shown in Table 2 uses a conversion factor of 105%, meaning that all actual rates at that time had been increased 5% since the class base rates were first standardized.[16]

Job Evaluation by Ranking or Grading.—Under the job ranking or grading plan, the titles of all jobs are written on cards, and the cards are arranged in a series of worth, each of which is known as a grade. It is done by several competent judges on the basis of the hourly rate which should be paid for each job, regardless of the

[15] A. M. A. Office Management Series No. 55.
[16] *A. M. A. Personnel,* Vol. 15, No. 3.

TABLE 2. EXAMPLES OF DETAILED RATING AND GRADING OF PLANT HOURLY-RATED POSITIONS

JOB	POINTS						Base Class	Hrly. Rate at 1.05 Conv.
	Mental Effort	Skill	Phys. Effort	Respons-ibility	Work. Cond.	Total Points		
Toolmaker Leaderman (Working gang-pusher) (Daywork)	27	37	16	22	5	107	106	$1.11
Gyroscope & Marine Instrument Repairman (Daywork)	28	34	17	19	7	105	106	1.11
First Operator—Pipe Still Battery (Shift work)	24	24	16	24	14	102	103	1.08
Ethyl Blending Plant Operator (Daywork)	19	21	21	22	21	104	103	1.08
Toolmaker, Machine Shop (Daywork)	24	34	19	17	5	99	100	1.05
Bricklayer, 1st Class, Outside Plant (Daywork)	17	28	30	14	11	100	100	1.05
Flying Squad. Man (Comb. pipefitter, boilermaker, rigger, welder) (Daywork)	23	20	27	14	10	94	94	.99
Shop Machinist, All-Around (Daywork)	21	29	24	15	5	94	94	.99
Pipefitter, 1st Class, Outside Plant (Daywork)	17	22	27	15	10	91	91	.96
Operator, Pipe Stills, Stabilization Plant (Shift work)	22	19	16	19	15	91	91	.96
Operator, Sodium Plumbite Plant (Shift work)	17	16	20	16	17	86	85	.89
Automobile Painter—Finisher, Striper & Spray (Night work)	16	24	25	12	9	86	85	.89
Asst. Engineer, Electrical Power House (Shift work)	14	19	19	17	9	78	79	.83
Tool Checker & Tester (Daywork)	28	11	19	15	6	79	79	.83
Ship Loader, Wharves (Shift work)	4	8	33	10	16	71	70	.74
Tester, Viscosity (Daywork)	18	20	15	11	6	70	70	.74
Boilermaker's Helper, Outside Plant (Daywork)	6	7	33	5	10	61	61	.64
Sample Room Attendant, Research Dept. (Daywork)	14	10	23	9	6	62	61	.64
Common (Heavy) Labor, Outside Plant (Daywork)	3	3	37	3	9	55	55	.58
Induced Draft Engine Tender, Boiler House (Daywork)	6	8	23	12	7	56	55	.58
Janitor, Pipe Still Battery & Pump House (Daywork)	4	3	30	4	9	50	49*	.52
Stencil-Cutter & Shipping-Tank Gauger (Daywork)	8	6	19	8	6	47	49*	.52

*Jobs totaling 50 points and under placed in minimum-rate class

present wage. The grades assigned to each job by all the judges are then averaged and this average considered the "score" for that job. Hourly rates are then assigned to jobs in order of their ranking, largely by arbitrarily deciding the rates to be paid the highest and the lowest jobs, and then seeking intermediate rates based upon the respective scores. This plan is weak because: (a) it is impossible to find many judges who are thoroughly familiar with all jobs being ranked, (b) present rates exercise an undue influence on the judges' minds, (c) the plan is based solely on opinions, and (d) judgments of equally competent graders frequently reveal such wide discrepancies that the averaging process becomes nothing more than a mathematical fiction.[17] The extreme of this was "Predetermined Grading" in which all office jobs would be arbitrarily classified into five to eight levels or grades, general specifications written for each grade, and salaries standardized accordingly.

Basic evaluation of an occupation should only take into account the inherent demands and characteristics of that occupation and should not include as a varying influence, supply and demand, rates already in existence in the particular organization or in the general locality, or any other outside influence on the emolument rate. While it is recognized that such influences are definitely in existence and will no doubt affect to some extent the final wage rates established, they are nevertheless not part of the basic value of an occupation.

One of the important things to be considered when attempting a program of this kind is to determine who should do the work of making the evaluation. That depends upon the circumstances involved, but it has been suggested that the most desirable individuals to establish such a comparative evaluation are those in the organization who control the employees who will eventually be affected by it, usually a committee composed of the supervisors of the hourly wage employees. One or more experienced "rate analysts" can, however, save the committee much time. He should be attached to the personnel staff.

Characteristics Roughly Considered.—Any attempt to evaluate jobs without some analysis is worthless. Hence it is necessary to determine divisional factors or characteristics of the work which taken together will account for successful operation. Perhaps the simplest set of characteristics which will serve this need is as follows:

1. Previous training. This division determines the minimum requisite schooling and working experience in order to fit an individual for work in a particular occupation.

[17] E. J. Benge, "Gauging the Job's Worth," *Industrial Relations*, Vol. 3, No. 3.

2. Inherent demands of an occupation, peculiar to the industry or factory under consideration. This division determines the skill required, accuracy demanded, as well as ingenuity and integrity required.
3. Physical conditions under which the work of an occupation is performed. This division determines health and accident hazards, disagreeable conditions, physical effort, etc.

The mental approach of those engaged in this program must be purely objective and the leader or rate analyst must be constantly on guard to keep all committeemen free from subjective tendencies. "The determination of the relative importance of these characteristics involves a broad visualization of the conditions applicable to the organization under consideration and the greatest care must be exercised not to allow a narrow consideration of individual cases or minor variations to influence the minds of those engaged in the evaluation."[18]

To illustrate, assume that the relative importance in these major characteristics is as follows:

1. Previous training	50%
2. Inherent demands	40%
3. Physical conditions	10%

The above figures might represent the opinion of the evaluating committee in the case of a high-grade machine shop or instrument factory, whereas if this work were being done for a steel mill, much greater importance would be attached to the third division of physical conditions and less to each of the other two. Evaluation of occupations in terms of the above three main divisions has been done as an aid to ranking with some success but better evaluation can be accomplished by using more characteristics, and assigning them point weightings. Usually that kind of analysis is very limited or lacking where the ranking method is used.

Procedure.—Jobs may already be classified broadly in four groups: manual, clerical, technical, and commercial. These are subdivided as to which sex is desirable, etc. The Westinghouse Electric & Manufacturing Company classifies all its jobs into seven groups as follows:[19]

Group	I	Policy	Group	IV	Creative
"	II	Administrative	"	V	Interpretive
"	III	Executive	"	VI	Skilled
			"	VII	Unskilled

18 W. W. Finlay, *Comparative Valuation of Occupations in Industry*, N. A. C. A. Bulletin, Vol. 19, No. 3.

19 Compare this with Table 1.

With this as a framework the few characteristics which seem most suitable can be set up. If possible some measuring scale should be contrived for each of these. Otherwise poor guessing may defeat the whole objective. Next it is necessary to find the key jobs or at least the end jobs for each departmental group of jobs. Now all the jobs in each departmental group must be compared according to the degree of some characteristic which it is believed the job requires relative to the key or end job requirements. On this basis the jobs are ranked in series and recorded. This is now repeated for each of the other characteristics. The final series must be a composite since a job which ranks high in one characteristic may rank low in others. Hence the independent judgment of several judges, usually departmental committeemen, is important and each should be recorded privately and more than once. When agreement is reached as to a ranking list it is then desirable to close up the jobs into classes[20] with an approximately equal interval maintained between adjacent classes, say 2 to 5-cent rate intervals. This does not mean that the old rates should be allowed to influence the judges except those for key or end jobs which were satisfactorily rated at the beginning or staked at this time as a policy.

Job titles may now be remade to get a truer significance as:

Class I—Diemaker No. 1, Patternmaker No. 1, Toolmaker No. 1
Class XVI—Lathe Operator No. 4, Milling Machine Operator No. 6
Class XIX—Assembler No. 5, Laborer No. 1, Janitor

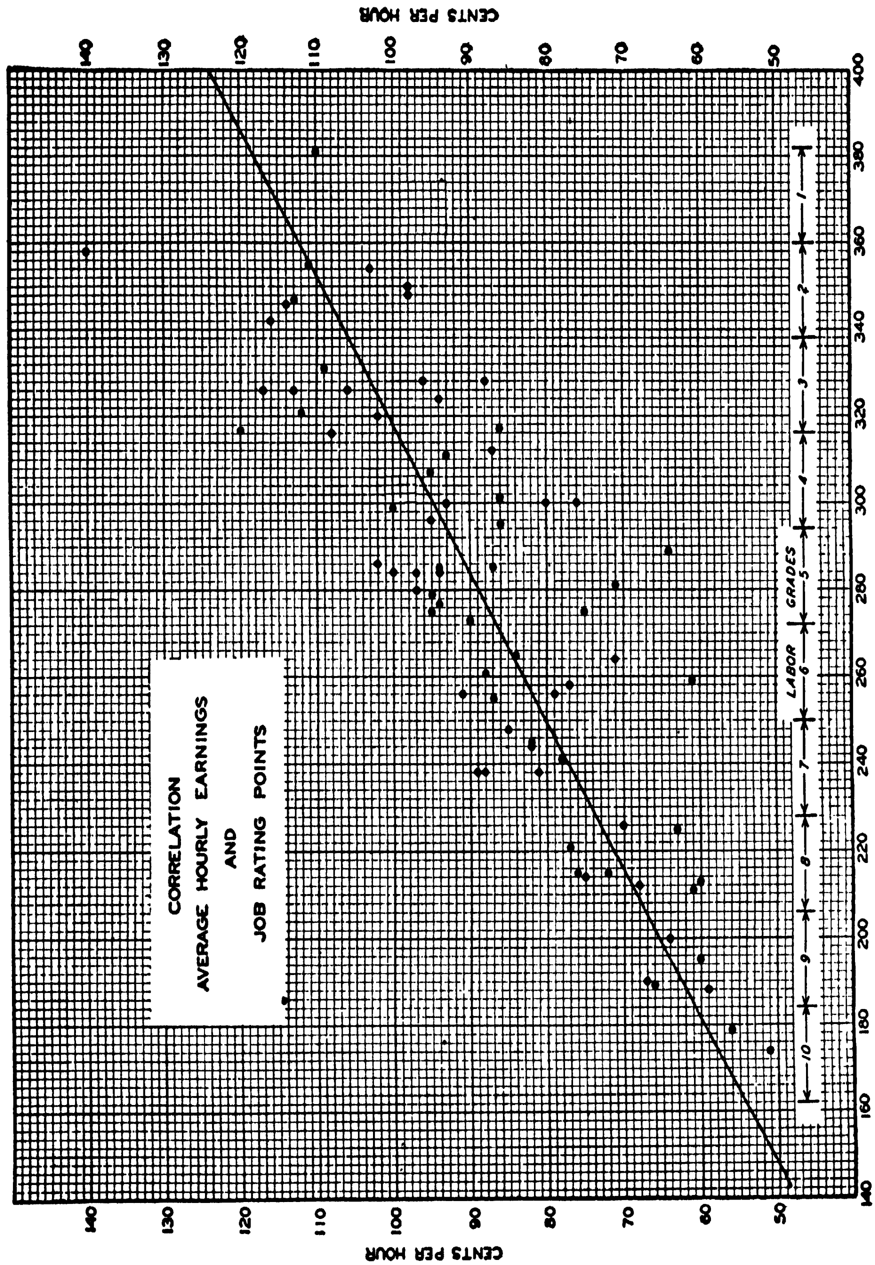
When this has been carried out for all departments a general committee, led by the same analyst, must harmonize the various lists.

The Scatter Diagram.—The next step should be to select a representative group of ten to fifteen standard hourly-rate key jobs, the rates of which range at intervals from near the lowest to near the highest rate, which have been in existence long enough to be well standardized, concerning which there has been no question as to adequacy of the rates, and which have been generally used in past rate setting as bases for comparisons with outside rates. One company found forty such jobs. If possible, they should contain a fair percentage of jobs which are common at least to the industry in the locality being studied. A so-called market survey of the rates paid these jobs should be made periodically.[21]

It is now possible to check the class rankings against the existing wage scale. The former are usually taken as the horizontal or

[20] One company reduced 400 jobs to twenty-three classes and another reduced 500 jobs to fifteen classes.

[21] *The Technique of Wage Negotiation and Adjustment,* by W. F. Cook, A. M. A. Personnel Series No. 30.



(Courtesy Nat. Metal Trades Assoc.)

Figure 4. Correlation Average Hourly Earnings and Job Rating Points

abscissas, and the wage scale as the vertical or ordinate, in cents per hour or dollars per week. The classes or jobs themselves are put on as points at equal or assumed horizontal intervals. Key or end jobs are assigned the prevailing or desired rate on the ordinate and the wage scale becomes fixed. The base rate for each class or job may now be ascertained by drawing horizontals to each point. If the range of classes is narrow it may be justifiable to assume that the points should all fall in a straight line (Figure 4), but this is not necessarily right and any such assumption may be wholly wrong.[22] When a smooth trend curve is found to be acceptable then the "out-of-line" classes or jobs may be readjusted, that is, brought back to the curve. Inconsistencies are most likely where jobs are highly specialized and consequently difficult of comparison. As these rates are minima a range of rates may be made for each class but this leads to overlapping and any such need may well be left for merit rating. This whole procedure needs to be repeated every five years or so.

Job Characteristics.—In any job evaluation program it must be remembered that the job only is being analyzed. The man-rating must come as a part of a separate program. Therefore, only characteristics which describe the job should be included in the study. Among the characteristics which have been found to correlate positively with wage rates are:[23] "scholastic content of the work, length of time typically needed by natively qualified but inexperienced operators to develop proficiency, physical resistance overcome by the operator during the work day, seriousness of possible errors on the job, originality of problems to be solved by the operator, degree to which the work is supervised, teamwork and personal contacts required of the operator, his supervision of others, hazards and disagreeable conditions which he must withstand at work, and any unavoidable expense caused him by conditions of his employment."

Manual skill has been defined as "the ability to do work marked by precision, speed and quick accurate adjustment of motion paths to complex,. intricate conditions." If we stretch this conception to include the knowledge and capability necessary to meet varying conditions together with the capability of improvement we find that skill so conceived is the most important of the major characteristics in all jobs lying between those classed as unskilled and those classed as supervision. This broad "skill" may be subdivided into mental and physical, into inherent and acquired, etc., but taking it broadly

22 "Job Evaluation," by Prof. J. E. Walters, *Mechanical Engineering*, Vol. 60, No. 12.

23 Seventh International Management Congress (1938) Bulletin, *Principles and Methods of Wage and Salary Determination*, by John W. Riegal, Director of Bureau of Industrial Relations, University of Michigan.

allows us to simplify the breakdown of characteristics. In short, the worth of all jobs can now be measured in terms of four major job characteristics:

1. Skill—that which must be (with whatever composes it) already possessed by the worker, *what he must bring.*
2. Effort—that *which the worker must exert.*
3. Responsibility—that *which the worker must assume.*
4. Working Conditions—*what the job does or can do to the worker.*

All of these basic characteristics are present to some degree in every job, but do not carry equal importance or are not present to the same degree in the various jobs. A survey published by the N.I.C.B.[24] indicates that the maximum weights given to these major characteristics by most industries fall within the following ranges:

1. Skill	27.8%–80.2%
2. Effort	4.7%–22.2%
3. Responsibility	4.4%–35.0%
4. Working Conditions	.0%–20.0%

These ranges of importance are unduly influenced by the inclusion of a few exceptional companies. Eliminating these extreme values from the above data, it can be said that the weights assigned by 60% of the companies fall within the following ranges:

Major Characteristic	Range of Importance	Median Importance
1. Skill	40.0%–64.3%	50%
2. Effort	10.0%–21.0%	15%
3. Responsibility	20.0%–27.8%	25%
4. Working Conditions	10.0%–20.0%	11%

While this "breakdown" into four major characteristics has become almost universal, there is great discrepancy as to further procedure. For thorough analysis the four major job characteristics are too broad and must be subdivided in order to provide a safer method of evaluation. The Industrial Management Society plan has twenty-three base and sub-characteristics while the National Electrical Manufacturers Association plan has eleven.

A survey reported by the National Association of Cost Accountants,[25] showed many variations in the job characteristics used by companies to help them in their job evaluation program. The following list summarizes these characteristics and shows the number of companies that use each characteristic in some degree. This report, however, makes no attempt to show how the various companies weight the characteristics which they use.

24 *Studies in Personnel Policies,* N. I. C. B. Bulletin No. 25, September, 1940.
25 A. S. Knowles and F. C. Means, N. A. C. A. Bulletin, Vol. 20, No. 7.

1. Skill
   Mental—Education required—13 companies
   Experience required—12 companies
   Physical—14 companies
2. Effort
   Mental—14 companies
   Physical—14 companies
   Fatigue—4 companies
3. Responsibility—17 companies
4. Working conditions—13 companies

The following headings which should have no bearing on the job rating program were also found to be in use.

1. Prevailing wage—4 companies
2. Opportunity for advancement—3 companies
3. Cost of living—2 companies
4. Profit of company—2 companies

They find the average number of subdivision in use to be seven and suggest that an ideal number to use would be seven or eight. A survey[26] of several companies having a job analysis program, shows that eleven characteristics are in common use, and they are distributed into the four main groups as follows:

1. Skill
   Scholastic content—7 companies
   Learning period—13 companies
2. Effort
   Mental application—2 companies
   Physical resistance overcome by operator—10 companies
3. Responsibility
   Seriousness of errors—11 companies
   Originality of problems—4 companies
   Degree to which work is supervised—4 companies
   Teamwork and public contacts required—4 companies
   Supervision exercised by operator—6 companies
4. Working Conditions
   Hazards and disagreeable conditions—13 companies
   Expense to operator—2 companies

From this study it appears that the median company uses seven job characteristics.

26 J. W. Riegal, *Wage Determination,* Bureau of Industrial Relations, University of Michigan, 1937.

TABLE 3. SUMMARY OF JOB EVALUATION CHARACTERISTICS

	General Foods Corp.	General Elect. (Wages)	General Elect. (Salary)	Revere Copper and Brass	U.S. Steel	Wright Aero.	Westing-house	American Optical	"A"	"B"	Cheney Bros.
SKILL											
Education	10		14.3		10	7.4	18.5		10	14	35
General		50						40			
Previous training	10				12	35.2	18.5			22	
Training time	10			16.6		13.3			20		
Details	10										
Resourcefulness	10					6.9					
Versatility	10										
Cooperation	10										
Mentality		12.5	7.1								
Analytical ability			14.3								
Initiative			14.3							14	
Personal requirements			14.3								
Manual dexterity				11.1	23						
Accuracy						19.5					
Aptitude							23.2				
Job skill									10		
Adjustability									10		
TOTAL	70	62.5	64.3	27.7	45	82.3	60.2	40	50	50	35

Effort											
Mental	10	6.25	3.3	11.1	10		7.4				
Physical		6.25	1.4	11.1	6	4.5	7.4			10	
Visual							7.4				
Fatigue					5					5	
Honesty of effort						1.7					
Monotony						.7					
Total	10	12.5	4.7	22.2	21	6.9	22.2	22	15	15	0
Responsibility for											
General	10	12.5	3.1					27	25		35
Cost of errors						4.4	4.6			5	
Quality and product	10			22.2			4.6			5	
Materials					9						
Equipment				5.5	5		4.6			5	
Safety of others					5		4.6			5	
Supervision			15.5	5.5	5					5	
Money			12.4								
Total	20	12.5	31.0	33.2	24	4.4	17.4	27	25	25	35
Working Conditions											
General		12.5		11.1				11	10	10	20
Health hazard				5.5	5	2.2				5	
Accident hazard						2.5					
Surroundings					4	.8					
Current expense					1						
Total	0	12.5	0	16.6	10	5.5		11	10	15	20

1. Westinghouse Electric and Manufacturing Company makes an allowance for unfavorable working conditions as a supplemental factor to the above characteristics.
2. General Electric Company allows 400 base points in addition to the above characteristics.
3. Wright Aeronautical Corporation includes a characteristic "difficulty of locating work elsewhere" which is not strictly a measure of job worth.

The N.I.C.B. Bulletin for September, 1940 reports a rather extensive survey made of industries using job evaluation. Nearly all of the job characteristics used by these companies can be divided into the four main groups as shown in Table 3. The average company in this report uses nine job characteristics.

From these studies of current practice, it seems to be the consensus of opinion that all jobs can be measured in terms of the four major job characteristics and that this number is usually not sufficient to measure easily and accurately the small difference between the various job classifications. The use of fifteen or twenty job characteristics gives this greater accuracy but entails an extraordinary amount of work when there are hundreds of jobs to be analyzed. Since Benge, Knowles, and Riegel all suggest that the number of subcharacteristics used should not greatly exceed seven, it might be well to subdivide each of the original four job characteristics into two subcharacteristics, making eight in all. An analysis of various surveys and reports suggests the following subdivisions which appear to be common to most jobs and might therefore be standardized.

1. Skill
    - Mental (Education, experience, training, etc.)
    - Physical (Manual dexterity, etc.)
2. Effort
    - Mental
    - Physical
3. Responsibility
    - For supervision
    - For material things
4. Working Conditions
    - Hazardous
    - Disagreeable

For salaried positions the characteristics may be the same but No. 3 (Responsibility) must be subdivided to separate the various kinds, as for:

(a) Other employees
(b) Materials
(c) Equipment
(d) Markets
(e) Money
(f) Methods
(g) Records

It may also be well to set up Mental Effort as a separate major

characteristic with subdivisions, or to include under No. 1 (Skill) such subdivisions as: personality, tact, honesty, cooperation, etc.[27]

Measuring Scales Important.—Job evaluation, to be wholly successful, must rest as far as possible on measurable data. Its purpose is to determine equitable base rates and these are all important to both employer and employee. The union advocacy of standard wage rates anticipated the problem but did not solve it. The job analyst can solve it but not without gaining the confidence of labor. Not only is employee cooperation necessary for determining the values but union approval is often necessary for sustaining them. Correct evaluation is too technical for mere bargaining but the results must give mutual satisfaction and the development of each rate may have to be explained to the union representative. Already a few employers are consenting to the *union demand for some degree of participation* in the procedure. With this in mind it is urgent that scales of measurement be found for as many characteristics as possible. Table 4 shows one of the earlier attempts to set up a scale for a few of the sub-characteristics of skill. Not only are some of the characteristics difficult to measure, they are even difficult to define. They must, however, be defined as well as practicable. The National Electrical Manufacturers' Association has done good work in this for the electrical trades and the National Metal Trades Association has done the same for machinist jobs.[28] Other employers' associations should follow their examples. In the meantime there is much discrepancy as between the definitions of one company and those of another.

Major Characteristics Subdivided for Rating.—Lacking a definite measuring scale the degree of any characteristic required in a job must be judged on a purely relative basis. To aid this process a scale of ten is arbitrarily set up with portions of it assigned to degree-divisions such as:

Exceptional.................	10–7 or to 4	(depending on the
Above average.............	7–4 " " 3	relative worth of
Little or none...............	1–0 " " 0	the subdivision)

Subdivisions of a major characteristic are now used as headings of vertical columns and the degree divisions used as headings of horizontal rows. On this background the job's degree of characteristic may be rated as shown in Table 5, in which case the subdivisions of skill are used by way of illustration.[29] Correct relativity is more easily secured if all or a majority of the jobs are *evaluated on a*

27 *Salary Determination*, by J. W. Riegal, Bureau of Industrial Relations, University of Michigan, 1940.
28 N. M. T. A. Job Rating.
29 A. M. A. Personnel Series No. 34.

TABLE 4. GRAPHIC SCALE FOR APPRAISING OCCUPATIONS AND POSITIONS*

(Sample characteristics only)

Payroll Title__________ Rater's Name__________

	0	2	4	6	8	10
A. Education needed by person of average intelligence to do work.	Grammar School	2 years High School	High School Diploma	H. S. plus Business or Vocational School	College Degree	College Degree, plus technical training
B. Previous experience in same or related work.	None	1 year	2 years	3 years	4 years	Over 4 years
C. Time for person of average ability to be trained on the job.	None	1 week	1 month	3 months	6 months	Over 6 months
D. Precision and accuracy required (machine work).	Rough work		.01″	.005″	.001″	.0005″
E. Chance of damage to machines, materials, or products.	Under $50/yr.	About $50/yr.	About $500/yr.	About $1,000/yr.	About $2,500/yr.	Over $5,000/yr.
F. Extent to which unforeseen difficulties require initiative and ingenuity	Work is wholly routine	Routine work with occasional problems (weekly)		Routine work with daily problems		New problems met constantly
G. Versatility required (No. of operations involved, e.g., milling, drilling).	1	2	3	4	5	6 or more

* Clerical Salary Study Committee Report No. 1, Life Office Management Assoc.

single characteristic before going on to other characteristics. Since skill is the most important of these, a complete evaluation of skill accounts for a large portion of the total points and the remaining portions will have minor influence. Thus a job which gets "exceptional" rating on all subdivisions will have a total rating of 36 for that characteristic. Some multiply all by 10 to get more working room. The subdivisions may be further defined and illustrated as a guide to their evaluation. If all this is repeated successively for each major characteristic, the treatment of various jobs will at least be consistent and objective if not rigidly scientific.

TABLE 5. RELATIVE RATING OF SUBCHARACTERISTICS IN SKILL

	Dexterity	Precision	Versatility	Adaptation Period	Ingenuity
Exceptional......	9	8 6	5	4	10 4
Above average....	6 5 4	5 4	5 4	3	3 2
Average.........	3 2	3 2	3 2	2 1	1
Little or none....	1 0	1 0	1 0	0	0

Three Methods of Analytical Evaluation.—Thus after the characteristics have been decided upon, subdivided, and defined, the worth of each job in terms of these characteristics can be determined. There are three general methods of making this determination.

1. The straight point method, that is, assigning of equal weight ranges to each characteristic.
2. The weighted point method, that is, assigning weights in points, or different point ranges, to each characteristic.
3. The direct to money method, that is, determining relative worth in cents only, not specifying any maximum limit.

Evaluating the Job—Straight Point Method.—When evaluating a job by the straight point method, an assumption is made that all of the characteristics should have ranges of values between the same maximum and minimum points. Some use as many as twenty job characteristics, each of which is evalued by the analyst from a minimum of 1 point to a maximum of 5 points, giving a total possible minimum score of 20 points and a total possible maximum score

of 100 points. The characteristics used by the Davison-Paxton Company of Atlanta in this program and its scale of rating are as follows:

EXAMPLE OF STRAIGHT POINT METHOD.[80] The example (Figure 5) is used only to illustrate the point system of job evaluation and is not meant to be taken as an ideal list of job characteristics. The only advantage offered by the straight point system is that some analysis of the characteristics is required. This advantage, however, can also be claimed for the other two methods of evaluating the job. The disadvantages more than outweigh the advantages, and are:

1. Too much dependence is placed on the arbitrary judgment of individuals.
2. It assumes that a considerable number of specific characteristics enter into the hourly rate for every job.
3. Stress is placed on the comparison of disparate characteristics constituting a job, rather than upon comparison of similar characteristics found in many or all jobs.

Evaluating the Job—Weighted Point Method.—The weighted point system of evaluating the job emerged in 1926. It attempted to overcome or to minimize the disadvantages of the straight point system. M. R. Lott,[31] who pioneered in the weighted point plan, proposed the following steps to put the plan into operation:

1. There are fifteen characteristics which influence the worth of the job. (See below.)
2. 100 points should be distributed over the fifteen characteristics to indicate their relative weights in the particular type of job to be studied.
3. Rates or points from zero to 10 should be assigned to each characteristic for each job to indicate to what extent that characteristic enters into the various jobs under study.
4. Score points should be determined for each characteristic of each job by multiplying characteristic values by assigned points (item 2 by item 3 above).
5. Total job scores should be determined by adding individual score points of each characteristic.
6. Select a skilled and an unskilled job which are generally standardized in the industry and plot their pay against the points assigned above and plot a wage rate point diagram.

The rates mentioned in item 3 above can be set up on a scale

[80] Taylor Society Bulletin, Vol. XIII, No. 4.
[31] Merrill R. Lott, *Wage Scales and Job Evaluation.*

SKILL	KIND	NONE	SLIGHT	AVERAGE	MORE THAN ORD	EXCEPT.
	MANUAL	●				
	NUMERICAL	●				
	VERBAL					●
INTELLIGENCE	KIND	NONE	ROU TINE	TRADE JUDG	SUP. JUDG.	MGR. JUDG.
	TECHNICAL				●	
	PRACTICAL				●	
PERSONALITY	KIND	NONE	LITTLE	ORD.	MORE THAN ORD	EXCEPT.
	APPLICATION RELIABILITY COMPANY INTEREST				●	
	TACT				●	
	FORCE				●	
	ABILITY TO TEACH OR SUPERVISE				●	
TRAINING	KIND	NONE	LIMITED	GOOD	MORE THAN ORD	EXCEPT.
	TRADE TRAINING				●	
	GEN'L EDUCATION				●	
	EXPERIENCE				●	
REPLACEMENT COST	VALUE	NONE	$10-19	$20-29	$30-39	$40-
	MARKET PRICE					●
	PRICE PERSON REQUIRED					●
OPPORTUNITY FOR PROGRESS	POSSIBILITIES	NONE	LIMITED	FAIR	GOOD	EXCEPT.
	WITH COMPANY				●	
	ELSEWHERE				●	
	TRANSFER POSSIBILITIES				●	
COMPANY TRAINING COST	COST	NONE	SMALL	ORD.	MORE THAN ORD.	CONSID-ERABLE
	LENGTH OF TIME				●	
	TRAINING LOSS	●				
	POINT VALUE OF RATING	0	1	2	3	4

Figure 5. Clerical Job Rating

Department—General Correspondence; Position—Section Chief, Adjustment Section; Job Rating Score—51 points.

basis to facilitate the assignment of weights. For example, Lott suggests that for the characteristic "Time Required to Learn a Trade" the following be used as a guide:

Years Experience	Points Assigned
10 or more	10
9–10	9
8– 9	8
7– 8	7
6– 7	6
5– 6	5
4– 5	4
3– 4	3
2– 3	2
1– 2	1

After these charts are made for each of the fifteen job characteristics, the work of assigning rates for each job is much simplified and less subject to the arbitrary judgment of the job analysis. Lott's choice of characteristics was as follows:

1. Time usually required to become highly skilled in an occupation.
2. Time usually required for a skilled person in the occupation to become adapted to the employer's needs.
3. Number of men employed in an occupation in the locality—the labor supply.
4. Possibility of an employee locating with another company with a similar earning capacity.
5. Educational requirements of an occupation.
6. Prevailing rate of pay in locality.
7. Degree of skill, manual dexterity, accuracy required.
8. Necessity of constantly facing new problems, variety of work.
9. Money value of parts worked on—possible loss to company through personal errors—unintentional.
10. Dependence that must be placed upon the integrity and honesty of effort of the employee.
11. Cleanliness of working conditions.
12. Exposure to health hazards.
13. Exposure to accident hazards.
14. Physical effort required.
15. Monotony of work.

These characteristics can be grouped under the four major headings for purposes of comparison with other plans as follows:

1. Skill—items 1, 2, 5, and 7.
2. Effort—items 8, 14 and 15.

3. Responsibility—items 9 and 10.
4. Working conditions—items 11, 12, and 13.

Best practice today conforms to the four major characteristics and retains them as headings even where further subdivisions are used. This lends orderliness to the procedure and allows comparison with the work of other companies. Perhaps it is too early to standardize very far but with varying subdivisions it is doubtful if the four major headings will ever need any addition or subtraction. Hence we may consider them standard.

Another practice which has much merit but is not so universal is the assignment of a fixed number of points for the job of least worth, the one given the fundamental base rate. On a maximum evaluation of 1,000 points for the highest theoretical job this bottom job is given 400 points and all other jobs are given the same 400 points as a foundation.[32] At the time these weightings were adopted most wage rates ranged between $.40 and $1 per hour and 10 points made a convenient amount to use per $.01. This recognized that at least 40% of all requirements are a normal body plus sanity and perhaps the ability to converse satisfactorily in an acceptable language. Thus in Table 6 seven key jobs are rated against that "dead load" as a starter.

TABLE 6. KEY JOB BASE POINTS AND FUNDAMENTAL BASE POINTS

Title of Key Job	Mental Requirement	Responsibility	Skill	Mental Application	Physical Application	Working Conditions	Above Fundamental Base	Total for Base
Diemaker 1	100	60	360	40	20	0	580	980
Patternmaker (wood)	100	60	340	40	20	5	565	965
Craneman (200 ton, 2 hooks)	35	70	120	30	10	0	265	665
Sand blaster	10	15	60	10	50	100	245	645
Air chipper	10	15	80	10	50	30	195	595
Sweeper	0	0	0	5	35	0	40	440
Fundamental	0	0	0	0	0	0	0	400

EXAMPLE 1 OF WEIGHTED POINT METHOD. The Wright Aeronautical Corporation is using the weighted point system of job evaluation. The program was installed throughout the Patterson plant by a committee of sixteen supervisors acting as a group in reaching

[32] *Job Evaluation*, by D. W. Weed, A. M. A. Production Series No. 111.

all of their decisions. Thirteen job characteristics were selected as describing all of the jobs and were weighted as follows:[88]

	Weight in Per Cent
1. Time required to learn trade	35.2
2. Time required to adapt skill to work	13.3
3. Difficulty in locating work elsewhere	.9
4. Educational requirements	7.4
5. Degree of skill and accuracy	19.5
6. Ingenuity	6.9
7. Cost of probable errors	4.4
8. Honesty of effort	1.7
9. Dirtiness of working conditions	.8
10. Exposure of health hazard	2.2
11. Exposure of accident hazard	2.5
12. Physical effort	4.5
13. Monotony of work	.7

After determining the above weights the committee assigned rates from zero to 10 points to each job for each characteristic. They did this by first determining the job which, in the combined opinion of the committee, should have the maximum value of 10 points, and then evaluating all other jobs by comparison to it. To facilitate this rating, charts similar to those previously described were used. In fact, the characteristic "Time Required to Learn Trade" was evaluated by allowing one point for each year required just as Lott suggested. The total points for each job were then found by multiplying each characteristic weight by the rate assigned to that particular job. The evaluation for patternmaker was as follows:

Characteristic	Rate	×	Weight	=	Total Points
1	10.0		35.2		352.00
2	3.5		13.3		46.55
3	0.0		.9		0.00
4	10.0		7.4		74.00
5	8.5		19.5		165.75
6	10.0		6.9		69.00
7	1.0		4.4		4.40
8	6.0		1.7		10.20
9	2.0		.8		1.60
10	1.0		2.2		2.20
11	8.4		2.5		21.00
12	1.0		4.5		4.50
13	0.0		.7		0.00
			Total		751.20

The jobs of toolmaker and of janitor were selected for the high and the low points of the wage rate-point curve. A straight line was drawn between these two points and this curve was used to calculate

[88] N. I. C. B. Bulletin, September, 1940.

JOB RATING SHEET

JOB NAME AUTOMATIC SCREW MACHINE OPERATOR DEPT. SCREW MACHINE JOB NO. ______

GENERAL JOB DESCRIPTION

Set up and operate automatic screw machines, such as #00, #0 and #2 Brown & Sharpe Single Spindle or 9/16" and 1" Acme Multi-Spindle.

JOB REQUIREMENTS

MAN WOMAN BOY SPEC. AGE REQ. 30-45 years

HRS. OF WK. (IF NOT REG.) Regular

REQUIRED EXPER. PREV. JOBS TIME 3 to 5 years on same or similar types of machines

APPRENTICESHIP Yes

DAY WORK RATE		AVE. HOURLY	OCCUPATIONAL
START	MAXIMUM	EARNINGS	WAGE
.85		$1.05	$1.02

JOB ATTRIBUTES	OBSERVERS EVALUATION 1ST DEG.	2 ND DEG	3RD DEG	4 TH DEG	5 TH DEG	POINTS ASGND
SKILL						
EDUCATION			✓			42
EXPERIENCE				✓		88
INITIATIVE & INGEN.				✓		56
EFFORT						
PHYSICAL DEMAND		✓				20
MENTAL OR VIS DEMAND				✓		20
RESPONSIBILITY						
EQUIPMENT OR PROCESS			✓			15
MATERIAL OR PRODUCT		✓				10
SAFETY OF OTHERS			✓			15
WORK OF OTHERS			✓			15
JOB CONDITIONS						
WORKING CONDITIONS				✓		40
UNAVOIDABLE HAZARDS			✓			15

TOTAL POINTS 336

LABOR GRADE 3

DETAILED DUTIES

1. Get necessary cams, chucks, tools, etc. from tool crib according to job layout.
2. Set up and adjust machine.
3. Grind and sharpen cutting tools and blades.
4. Operate group 2 to 5 machines depending on work requirements.
5. Determine proper feeds and speeds, where not specified.
6. Maintain tool set-up.

SPECIAL QUALIFICATIONS

1. Work from prints and job layouts.
2. Able to select proper cams, tools, chucks, cutters, blades, etc. if not specified on layout.
3. Work to close tolerances using complicated tool set-ups.
4. Able select proper cutting lubricant.
5. May direct the work of helpers.
6. Education equivalent to grammar school plus 4 years apprenticeship.

SAFETY REGULATIONS AND HAZARDS

Remote possibility of dermatitis from cutting oils and lubricants.

Figure 6. N. E. M. A. Job Rating Example

all of the other hourly rates. A safer method is that of the U. S. Steel Corporation subsidiaries which plots the relative locations of thirty-six key jobs, derives a smooth curve to fit, and then interpolates.

EXAMPLE 2 OF WEIGHTED POINT METHOD. One of the most widely used plans is that of the National Electrical Manufacturers Association, developed under the leadership of A. L. Kress.[84] We submit their choice of characteristics showing allotted points (Table 7) together with a typical job rating sheet (Figure 6).

TABLE 7. N. E. M. A. CHARACTERISTICS AND WEIGHTS

SKILL—Total Maximum Points		250
1. Education—maximum points	70	
2. Experience—maximum points	110	
3. Initiative & Ingenuity—maximum points	70	
EFFORT—Total Maximum Points		75
4. Physical Demand—maximum points	50	
5. Mental or Visual Demand—maximum points	25	
RESPONSIBILITY—Total Maximum Points		100
6. Equipment or Process—maximum points	25	
7. Material or Product—maximum points	25	
8. Safety of Others—maximum points	25	
9. Work of Others—maximum points	25	
JOB CONDITIONS—Total Maximum Points		75
10. Working Conditions—maximum points	50	
11. Unavoidable Hazards—maximum points	25	

Evaluating the Job—Direct to Money Method.—While the weighted point plan overcomes most of the disadvantages of the straight point plan, one still remains. This is the disadvantage of assigning maximum weights to the job characteristics. A plan which makes no provision for extremes in job characteristics such as the health and accident hazard or the poor working conditions of such jobs as caisson work is limited. The following points for developing an unlimited program have been suggested:[85]

1. The evaluation scale should be expressed in cents per hour, not in points.
2. The number of characteristics on which job judgment should be based should not exceed seven.
3. Job specifications should be subdivided into the same categories as the evaluation scale.

[84] N. E. M. A. Industrial Relations Bulletin No. 43.
[85] E. J. Benge, "Gauging the Job's Worth," *Industrial Relations*, February-March, 1932, and *Manual of Job Evaluation*, by Benge, Burk and Hay, Harper & Bros., 1941.

4. There should be no upper limit to the amount allowable for a given factor, so providing a scale sufficiently flexible to take care of new jobs, and of the extreme importance of a single characteristic.
5. There should be some means of comparing each characteristic of a particular job against that characteristic in comparable jobs, rather than against a predetermined scale for that characteristic.
6. Repeated judgments of a group of competent persons, using the job specifications, and spread over a considerable period of time, should be pooled to yield the final figures.

In this method, after the job characteristics are selected, ten key jobs whose rates are believed to be correct are picked, and the present wage rates of these jobs are distributed by each analyst to the job characteristics. The analysts are then asked to rank the jobs for each characteristic in the order of the degree to which that characteristic is present. This serves to check and to show up any errors that were made in the original distribution of the wage rate to the various characteristics. These discrepancies can be discussed by the committee and corrections can be made in the distribution. Every other job can then be evaluated by comparison to the ten key jobs. This is usually done by rating all jobs for one characteristic at a time and assigning a definite wage rate to each job for each characteristic. The total wage rate then will be the sum of the individual rates assigned.

Example of Direct to Money Method. The Atlantic Refining Company[36] uses a modified form of the Benge system of job evaluation. The job rating committee was made up of five job analysts and five operating representatives. The following job characteristics were selected as being critical factors in that particular industry:

1. Skill
2. Mental effort
3. Physical effort
4. Responsibility
5. Working conditions

(Note that No. 2 and No. 3 are the subdivisions of the second major characteristic "effort" previously "standardized.)

The first concern of the rating committee was to select fifteen key jobs. These jobs had to be common to the industry, they had to involve a range of wage rates, and they had to be jobs whose wage rates were not questioned. The names of the fifteen key jobs were

36 *Personnel*, February, 1939.

PAYROLL TITLE Operator

ALTERNATE SHIFT TITLES Houseman

DEP'T(S) Pt. Breeze Ref.—Refining

APPROVAL H. V. Hume

DIVISION(S) Cracking

LOCATION(S) Polymerization Unit

DESCRIPTION OF DUTIES

Under immediate supervision of assistant shift foreman in charge of poly. plant operations; exercises immediate supervision as necessary over engineer and fireman and personally performs duties in control house and on operating platform for attaining and maintaining required temperatures, pressures, levels, and flows for the safe and efficient operation of the poly. plant in receiving and purifying refinery gases by removing the hydrogen sulphide; for preparing the gases for polymerization by removing those constituents which are too light or too heavy for polymerization by absorption and fractionation; for polymerizing the prepared charge by use of high temperature and high pressure and subsequent fractionation and condensation to separate the poly. gasoline produced and to recover those components fit for further polymerization.

Receives oral orders from assistant shift foreman concerning any special operating conditions, otherwise performs the work in accordance with routine and accepted methods. Continuously observes indicating and recording temperature, pressure, flow and level gages and instruments on panel in control house. Attains and maintains specified operating conditions by adjustment of remote-control mechanisms and valves in control house and on operating platform. Observes furnace temperatures and makes adjustment from control house when burning gas, or orders fireman to make required adjustments when burning fuel oil. Observes temperatures in towers, condensers, coolers and accumulators, and adjusts to required temperature by regulating flow of cooling water or propane refrigeration, by regulating steam to reboiler, and by regulating reflux rates. Observes rates of flow through all parts of the equipment and makes adjustment with remote-control instruments, or orders engineer to make adjustments at the pump. Hourly, fills in poly. plant operating log for both recovery and polymerization systems. Calls any unusual variations to attention of assistant shift foreman and assists him in bringing the operation back to normal. Checks operation of automatic pressure controls on absorber and poly. tail gas, and operates emergency pressure control on hydrogen sulphide to acid plant. Regulates water on coolers cooling gas for the purification system. Regulates steam on heaters heating gas to expanders. In emergency, operates emergency stops for all pumps at poly. unit from wall outside control house. In emergency and on order of assistant shift foreman, operates emergency control for dropping furnaces out and putting steam on furnaces.

SPECIFICATION NUMBER	PAYROLL TITLE		RATES
350	Operator	TOTAL POINTS 101 BASE CLASS 100	CONV. 1.05 = $1.05

Figure 7a. Hourly Rated Job Specification

Personal Qualities	Reliability 30%	Observation 25%	Practicality 15%	Thoroughness 15%	Industry 15%

MENTAL EFFORT 24	SKILL 23	PHYSICAL EFFORT 16	RESPONSIBILITY 22	WORKING CONDITIONS 16
FORMAL EDUCATION OR EQUIV. H. S. 2 required KIND OF SPECIAL EDUCATION None KIND OF TECHNICAL KNOWLEDGE None HIGHEST MATHEMATICS USED Percentage X READ BLUEPRINTS ENGLISH Complete JOB INSTR. REC'D *Job*—oral—written—routine *Method*—self—oral—routine—written JOB INSTR. GIVEN *Job*—oral *Method*—oral C GRADE OF INTELLIGENCE REPORTS Find and enter	SKILL REQUIRED TO START ON JOB Thorough knowledge of the operation of this unit. Names and location of all parts of the unit. How to maintain and attain oper. cond. by use of remote-control mechanisms and valves. How to start up and shut unit down. PREVIOUS TIME TO ACQUIRE AND WHERE 6 to 12 months as engineer at this location, plus 6 to 12 months in lower-grade job at this location. ADDITIONAL LEARNING TIME REQ. ON THIS JOB 1 week FURTHER TIME REQ. FOR PRACTICE BEFORE NORMAL PROFICIENCY 1 month PRECISION LIMITS AND DECISIONS Decisions for adjusting flows, temperatures, pressures and levels within routine limits. May not deviate from routine except in emergency.	ACTIVITY Walking Standing OPERATION Varied CONTINUITY Intermittent REQUIRED REST PERIODS None STARTING AGE LIMITS 24—55 HEIGHT AND—OR WEIGHT Normal SEX AND COLOR M.R.—W.R. STRENGTH Normal EYESIGHT Normal HEARING Normal ABNORMAL FATIGUE None	FOR EQUIPMENT For oper. control and entering data according to routine of special instructions in order to maintain safe and efficient operation. FOR TOOLS None FOR MATERIALS Raw: purified refy. gases. Processed: poly. gasoline, absorption oil, gases. FOR SPECIAL SAFETY PRECAUTIONS Plant rules and spec. precautions. FOR SUPERVISION EXERCISED Immediate supervision of engr., fireman as necessary. FOR SUPERVISION RECEIVED Immediate supervision of asst. shift foreman.	PLACE Indoors—90% Outdoors—10% SURROUNDINGS Desk — control panel and instruments, high press. and high temp. poly. equip. Clean, orderly. ATMOSPHERE Normal and natural. Some fumes and odors. TEMPERATURE Normal and natural. ILLUMINATION Natural and good artificial. HAZARDS Strains to nerves plus usual hazards of high press. and high temp. stills. PROMOTIONS To assist shift foreman. REGULARITY OF INCOME Steady HOURS Regular shift.

Special Remarks:

Figure 7b. (*Reverse of 7a.*)

written on cards, and each member of the committee was asked to sort the cards privately into the order of importance for the characteristic "skill," basing his decisions on the job specifications which had been previously drawn up by the job analysts. This ranking was repeated for each of the other characteristics. About three weeks later and without forewarning the committee members were asked to rank the jobs for the second time for the same characteristics. Again at the end of another three weeks a third ranking by each committee member was asked for. These thirty rankings were then averaged, and the averages discussed and adjusted in a committee meeting.

The individual members of the rating committee were then asked to distribute the present wage rates of the key jobs over the five job characteristics. This distribution was also repeated twice at intervals. These distribution sheets were then checked against the rankings made above, and it was found that five of the key jobs were "out of line." These five jobs were excluded from the key list.[37] The final result of this rating was five measuring sticks each of which had a wide range of values and each of which was marked off in ten intervals against which every job in the plant could be compared. The five job analyst members of the rating committee ranked each job against each of the five measuring sticks mentioned above. The other members of the committee criticized and adjusted the rankings.

The disadvantage most often cited against this method of job evaluation is the difficulty of distributing wage increases after the plan has been installed. The Atlantic Refining Company meets this difficulty by granting only general wage increases to all hourly workers. At the time of the installation of the system, a general increase of 5% was made effective. The point ratings were corrected simply by multiplying each job rate by the factor 1.05 (Figures 7a and 7b and Table 2).

Example of Evaluating a Complete Series. Since job evaluation aims to correct "out-of-line" rates it is highly important to find the true line early in the procedure. J. O. Hopwood of the Philadelphia Electric Co.[38] studied all jobs up to departmental and associate management. With this more complete series he found that the trend line was approximately a parabola, that is, the slope increased as it ascended (Figure 8). He began by classifying the jobs into levels and functions, allowing a range of values for each level (Table 8). The rates here shown are not actual but assumed

37 The fact that key jobs are out of line may mean that the line is wrong, particularly if a straight line is imposed.

38 J. O. Hopwood, *Salaries, Wages and Labor Relations*, 1937, and A. M. A. Management Series No. 55.

for illustration. Note the use of ranges. It is difficult to avoid their use for the higher jobs. The mid-points are the ones derived by evaluation and the maxima and minima limits are set above and below to provide for four or five rates with about 10% differentials. Twenty to 30% are the more usual limits from the mid-points.[39] While it is possible to fix ranges which do not overlap it provides more latitude to let the maximum of the first grade extend to the mid-point of the second grade and start the minimum of the third grade at the mid-point of the second grade, etc. This allows hiring at rates below the normal and provides incentive within each grade without destroying the promotional program. The Industrial Management Society plan disregards specific grades altogether and allows a 20% range for every job. This is more confusing since the individual jobs are likely to come close together in rates. In any case the changing of rates for the employees should not come too easily or else there will be constant pressure to get the next rate and discontent for all who are below the top rates.

When salaried positions are included as in the Hopwood example, monthly rates must be translated into hourly rates, or vice versa, for the sake of a common ground. The advance classification of this plan can be extended through subdivisions as much as may be needed. For instance grade A will include A_1 to A_8, etc. Thus the letters can indicate the functional nature and the numbers indicate the levels of worth (Table 1).

Rate Structure for Wage Earners.—After jobs have been either ranked or weighted (points) some determination must be made of the wage rates that are to be paid for the various levels of work from the lowest to the highest ratings. This determination must be based on, or checked by, a survey of rates currently being paid in the locality on selected key jobs.[40] These key jobs must be stable jobs about which there is little or no chance of controversy concerning wage rates or, to the same end, they must be jobs which can be easily identified and compared with similar jobs in other plants.

When the evaluation process has been completed, a practical rate structure must be devised. That is, the entire series of jobs must be divided into groups of labor grades or classifications, each grade having a fixed compensation or compensation range. The ranging method results directly in such a structure with the disadvantage, however, that the number of classifications is limited and the difference in compensation between adjacent grades is usually quite large.

[39] *Translating Ratings into Rates*, by S. L. H. Burk, A. M. A. Personnel Series No. 49.

[40] W. S. McNeill, *Formula for Wage Adjustment*, also Leeds & Northrup Co. Adjustment Program, *A. M. A. Personnel*, Vol. 18, No. 2.

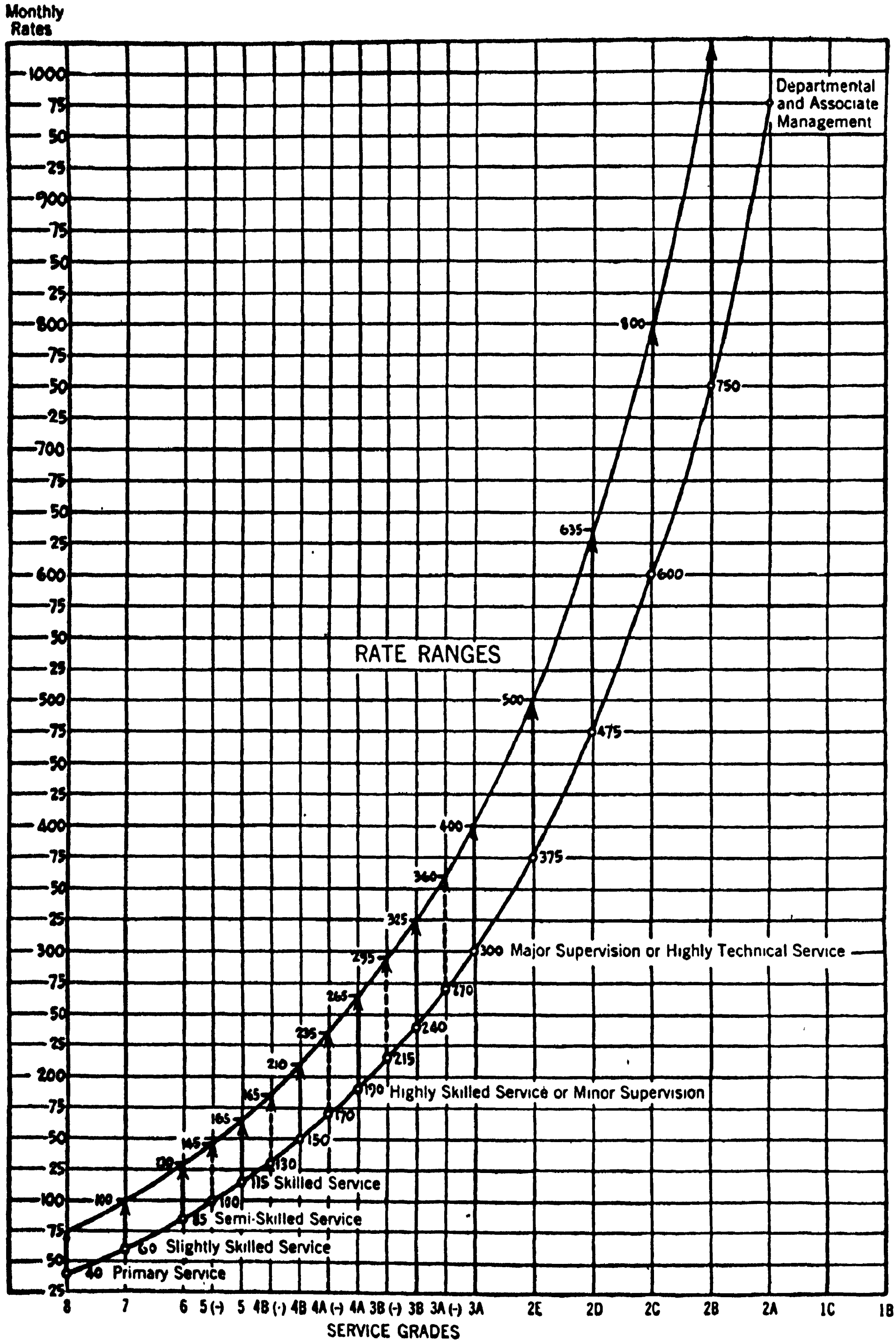


Figure 8. Rate Gradation of Minimum and Maximum Rates by Service Grades

TABLE 8. COORDINATION OF SERVICE GRADES AND RATE RANGES*

SERVICE GRADES		FUNCTIONAL CLASSES							RATE RANGES
		Accounting	Boiler Operating	Clerical Service	Designing	General Administration	Machine Construction	Selling	Monthly Basis
I. MANAGEMENT:									
1. General Management	A					President			$2,500-4,500
	B					Vice President			1,700-2,800
	C					Gen'l Mgr.			1,250-1,850
2. Departmental and Associate Management	A	Comptroller							$975-1,350
	B								750-1,025
	C	Gen'l Auditor							600 - 800
	D				Mechanical Engr.			Sales Mgr.	475 - 635
	E	Auditor				Executive Asst.	Plant Supt.		375 - 500
II. OPERATING PRACTICE									
3. Supv. or Highly Tech. Service	A	Sr. Accountant			Chief Designer			Jobbing Salesman	$300 - 400
	B	Accountant			Senior Designer		Machinist Foreman		240 - 325
4. Highly Skilled or Minor Supervision	A	Jr. Accountant	Boiler Engr.	Chief Clerk	Designer		Machinist 1st Cl.		$190 - 265
	B	Bookkeeper	Asst. Boiler Engr.	Senior Clerk	Asst Designer		Machinist 2nd Cl.	Salesman in Sales Room	150 - 210
5. Skilled Service		Asst. Bookkeeper	Boiler Operator	Clerk A	Junior Designer		Bench Hand		$115 - 165
6. Semi-Skilled Service			Stoker Operator	Clerk B	Draftsman		Machinist Helper		$ 85 - 130
7. Slightly Skilled Service			Ashman	Asst. Clerk	Tracer		Laborer		$ 60 - 100
8. Primary Service				Junior Clerk	Junior Tracer		Shop Boy		$40 - 75

* Titles, placements, and rate ranges are illustrative only.

The point method, on the other hand, makes it possible theoretically to arrive at a compensation in cents per hour for each individual job. This is usually considered a little too refined and a rate structure is set up with a difference of at least $.02 per hour between each grade with each grade defined by the corresponding point range. The rate for each grade can be expressed in cents per hour or in per cent of the rate for the lowest grade.

Many companies, instead of setting a fixed compensation rate for each labor grade, use a compensation range so that minor wage adjustments may be made according to merit rating for any individual employee without demotion or promotion. A total spread of from 20% to 30% is usually considered adequate for each grade. This may have a serious disadvantage, however, in that employees

are likely to press for the maximum rate of their grade and, if the plan is at all arbitrary, it provides opportunity for foremen and supervisors to show favoritism. Having a range for each grade usually means that grades are allowed to overlap. Thus one method of fixing the range for each grade is to say that the standard wage in one grade is the maximum for the grade below and the minimum for the grade above. The rate paid unskilled beginners is usually the rate for several grades below.

A typical rate structure without overlaps is one used by Revere Copper and Brass Incorporated.[41] It establishes definite rates approximately 5% apart from \$.50 to \$1.35 which follow approximately a straight line wage curve. This scale is shown in the tabulation below:

\$.02 Intervals	\$.03 Intervals	\$.04 Intervals	\$.05 Intervals
\$.50	\$.60	\$.78	\$.90
.52	.63	.82	.95
.54	.66	.86	1.00
.56	.69	.90	1.05
.58	.72		1.10
.60	.75		1.15
	.78		1.20
			1.25
			1.30
			1.35

The company's policy regarding general wage adjustments is that when a general increase or decrease is to be made all jobs will be shifted up or down the same number of steps. The standard is the base for incentive workers which makes it possible for them to earn above the evaluated rate. One step below the evaluated rate is assigned workers not fully qualified and two steps below is assigned beginners.

The Wright Aeronautical Corporation[42] has 30 labor grades for its hourly rated employees with hourly rates increasing in alternating steps of \$.03 per hour and \$.02 per hour. A portion of the scale is shown below:

\$.70	\$.80	(after which there are increasing increments to \$1.35)
.73	.83	
.75	.85	
.78	.88	

Rate Structure for Salaried Employees.—The Pennsylvania Company, a commercial bank and trust company in Philadelphia,

41 N. I. C. B. Studies in Personnel Policy No. 25.
42 N. I. C. B. Studies in Personnel Policy.

uses a point evaluation system for about 1,200 salaried employees. Its overlapping rate structure is given below:

Salary Grade	Monthly Salary Minimum	Monthly Salary Maximum
A	$ 50	$ 67
B	55	73
C	60	80
D	66	88
E	72	96
F	79	105
G	86	115
H	94	126
I	103	138
J	113	151
K	124	165
L	136	181
M	149	198
N	163	217
O	178	238
P	195	260
Q	214	285
R	234	312
S	256	341
T	280	374
U	307	409

When an employee reaches the maximum salary for his job he knows that no further increases will be forthcoming until he is promoted to a job in a higher grade.

Transfer.—Where there is no compensation range for each grade, no particular problem arises when transferring workers from one grade to another, the worker is merely paid the standard compensation for the grade to which he is transferred. In the case of temporary transfers to help another department catch up, etc., the worker should be paid the rate for his regular job. A good policy where there is a range for each grade is to pay a worker, being transferred upward, the rate nearest his previous rate and, when being transferred downward, the evaluated rate for the new job.

Maintenance of Rate Structure.—The job evaluation study and development of the rate structure is not the end of the problem. The system set up must be maintained. New jobs will have to be evaluated. Periodic wage surveys will have to be made and maladjustments thus discovered and corrected. Some method of dealing with employee complaints on wages should be formally established. A committee on wages, to which all wage complaints are referred, should be maintained. This committee should have only advisory authority, however, final decisions being left to the production executives.

Occasionally, one type of skill will come into great demand and workers in that field will be able to demand higher wages. Such a situation can be met by putting the occupation into an irregular classification and paying whatever rates are necessary to prevent the workers from going to other employers. Great care must be taken to be sure that conditions really justify the increase and that it is not merely a case of yielding to concerted but artificial pressure by one group. In regard to wage agreements with employee groups or unions, it must be remembered that any labor agreement becomes vulnerable as soon as it becomes decidedly disadvantageous to either labor or management. Despite this instability evidence is accumulating that union agreements are contributing to mutual satisfaction. When the leaders of each side are well informed and reasonable in intention, the hearings before an impartial chairman are truly democratic and constructive.

Differentials for Individual Merit.—Since base rates set by modern job evaluation are of necessity for minimum acceptability it becomes essential to provide for the extra values which are contributed by individual workers. Promotion is, of course, the most satisfactory solution,[43] but it is not always possible or always desired. There are many instances where individual workers must remain for years on the same jobs or within the same class of jobs. Most of such individuals acquire through experience either extra skill or judgment which results in more or better product per hour. In other cases their production may not increase but they have additional value through dependability, loyalty, versatility, ability to assume responsibility, ability to instruct, etc. For any of these assets they expect, and should be conceded, additional pay. Under an incentive plan much of this may be attained automatically, but even so it is common to figure incentive wages in terms of standard hours through which the hourly rate can vary according to individuals. In short, there are many reasons for adding to the base rates what are termed *individual differentials.* As in the case of base rates themselves, these extra rates must not be left to arbitrary dickering. Here "man-rating" finds its proper place. Each company should formulate policies to cover this need and adopt one of the many systems of merit rating (see Chapter 17) so that the individual differentials will truly reflect worth. Seniority regardless of merit is essentially a problem in the order of layoff and rehiring but it may also be a consideration for promotion in which case individual rate

[43] "Developing Promotional Opportunities," by H. B. Bergen, *A. M. A. Personnel,* Vol. 15, No. 4.

differentials will be involved. Union agreements have affected company policies considerably in this recently.[44]

Merit rating requires a range of adjustment, usually 20% to 33⅓%, above the base rate. Changes are made periodically, say every six months, and in accordance with weighted points by which five or six man-characteristics may be rated. By way of example suppose the total of points is 100 and the job base rate $.60 per hour. The range would then be between $.60 and $.80 as follows:

Credit Points	Hourly Rate
100	$ .80 (maximum)
90	.76
80	.72
70	.68
60	.64
50	.60 (minimum)

Adjustment of Out-of-Line Rates.—It is usual to bring up at once below-line payroll rates to the derived rates. On the other hand it is not always feasible to reduce those payroll rates that have gotten out of line above. To avoid all downward adjustment it is possible to (a) promote overrated operatives to higher class jobs where their old rates will fall within the derived limits; (b) if promotion is not practical, maintain status quo and exclude such operatives from participation in the general wage rise if any occurs; (c) hire new operatives at the derived rates and ultimately transfer the overrated ones using training if necessary to prepare them for other jobs. An evaluation case recently reported showed that 2,000 operatives had received increases in rate, 1,200 received no change and 3,800 received slightly lower rates. Payrolls were decreased 4% to 10% or an average decrease of 4.6%.

The Procedure Must Be Standardized.—A superficial job evaluation is valueless if not actually dangerous. To keep it dependable and worthy of confidence it is essential that the procedure itself be standardized and in writing. Organization of plant and departmental committees must be established, sub-committees planned to save time, etc. Characteristics suitable to the work must be decided upon and scales of points allocated. Definitions and measuring scales must be prepared for the characteristics. Selection of key or anchor jobs must be made to reach each class if possible. The number of classes may depend on that. Forms for job description-specifications must be designed. The order of all steps and techniques for taking them will need to be standardized. Finally arrangements for making adjustments and for settling grievances must be set up.

[44] N. I. C. B. Studies in Personnel Policy No. 5 and Research Memorandum No. 3.

Unless all this is developed in advance there are sure to be irregularities which will disqualify the results of the evaluation. Since all evaluations are relative to a few bases, detailed rules, and adherence to them, are more important for this procedure than for some other management activities.[45]

Cost of Doing Job Evaluation.—According to a recent report[46] a large steel company, which had evaluated 3,000 jobs involving 7,000 operatives, claimed that cost of installation amounted to .5% of the payroll. An oil refinery, where 7,000 employees out of 12,000 were covered by job evalution, reports exactly the same percentage cost for installation and adds that continued maintenance costs .1% of the payroll. The cost of getting the facts, setting up definitions, etc., constitutes the bulk of the expense. Thus the cost does not vary materially with the method of evaluation used. Its installation costs more in percentage for a small company and its maintenance costs more for any company as the application extends to higher salaried jobs. The refinery mentioned above found that 10,000 jobs seemed to be the economical limit for such extension. For 7,000 jobs it is necessary to employ permanently about eight analysts. Another company reports six analysts to maintain the work for 4,000 employees, 1,000 different jobs evaluated.

By way of caution it should be stated that in installing a job evaluation plan there is need for thorough selling.[47] Most companies take pains to *explain every step to employee representatives.* In doing this the jobs in question may be explained in detail, taking each characteristic by itself. Thus it should be possible to convince labor of the facts or be convinced by labor if the "facts" are inaccurate.

Uses of Job Evaluation.—Following is a tabulation of the uses that should be made of a *job evaluation program:*[48]

1. To determine qualities necessary for a job when hiring new employees.
2. To determine qualities necessary for a job when making promotions.
3. To determine if system of advancement in the particular plant is from job of lowest order toward job of highest order.
4. To determine qualities necessary when bringing back men who have been laid off.

[45] *Job Evaluation and Merit Rating,* by E. J. Benge, Nat. Foremen's Institute, Inc., 1941.
[46] "What's Your Job Worth," by H. B. Roberts, *The Iron Age,* Vol. 144, No. 8.
[47] *Selling Job Rating,* by W. R. Coley, A. M. A. Personnel Series No. 39.
[48] "Job Rating by Eugene Caldwell," *The Iron Age,* Vol. 144, No. 10.

5. To support explanations to employees as to why a particular man would not be suitable for a given opening. Many seniority clauses give preference to length of service only after the requirements of the job in the way of experience, etc., are satisfied. Fact that the job rating has been made up by an independent agency as well as the fact that the entire plant was rated and not specific data on the job in question obtained will carry weight.
6. To determine if men now occupying various jobs have qualifications required by the specifications.
7. To determine if all men are placed to best advantage in respective jobs available.
8. To analyze hourly rates and to determine if they are in line with rating given.
9. To compare wage rates with similar occupations at other local plants.
10. To point out where greatest opportunities lie for development of automatic equipment and improvement of working conditions. Obviously a company would be in a much better position if all jobs could be reduced to level of the lowest rating, thus making it possible to employ all unskilled labor, working under ideal conditions. This point should be explained more fully. Any plant where job ratings are very high, indicating a predominance of highly skilled labor, usually is a plant where there are very few automatic operations. High ratings indicate places where it is most likely that improvements in equipment can be justified.
11. To train new supervisors. Obviously, specifications outlining duties of each man are useful in starting a new foreman on the job.
12. To facilitate explanations to an employee of fact that any improvement in working conditions theoretically should mean a reduction in his wage rate. For example, if a worker is located in an unheated building and he insists on heat, resulting installation of heating equipment, this improvement in working conditions lowers his job rating. Theoretically, rate for the job should be lowered accordingly.

It is not advocated that automatic machines be installed or that better working conditions be provided for the express purpose of lowering workers' rates. However, if employee is shown that he is paid a higher rate because his working conditions are not the best, he will probably be better satisfied with his job.

SUMMARY OF STEPS.—To accomplish these results, Mr. Caldwell continues, it is necessary to give the following attention to details of the *survey after specifications are drawn* and rating work completed:

1. Check specifications to see if there is agreement with rater's opinions.
2. Determine if all jobs are included.
3. Establish consecutive numbers to jobs for identification.
4. Check number of men occupying each job.
5. Keep accurate running records of number of jobs and number of men occupying each job.
6. Determine by personal judgment whether the various elements used in making ratings are correct and logical to use as a basis for wage rates.
7. Check wage rates and determine how they vary from the normal for each job.
8. Set up wage rate bands for each job.
9. Consider wage adjustments to get existing rates more in line with the theoretical.
10. Consider the elimination of hourly man-rates altogether, establishing in their place a rate for each job.
11. Analyze each man to see if he has the requirements called for in the specifications for his particular job.
12. Consider a semi-rigid schedule of promotions from jobs of the lowest rating to those of higher ratings.
13. Consider if the individual employee involved should be shown how his particular job has been rated.
14. Get an overall picture of the types of labor used in the plant in question.
15. As new jobs occur set up new specifications for them.
16. As conditions are changed or machinery installed, the specifications for the particular job should be changed as well as the ratings.
17. Check a merit rating system for each individual employee to determine how well he fits into the job specifications.
18. Improve equipment and working conditions to reduce all jobs as far down the grading as is possible. An explanation of just what is meant by this statement has already been made.

CHAPTER 2

DEVELOPMENT OF WAGE INCENTIVE PLANS

The factory manager of today is still troubled by the problem of finding the wage incentive plan best suited to conditions in his particular business, probably the oldest problem in industrial history.—D. B. Kift.

Incentives Needed by Employers.—In 1940 the profits of American corporate business were down 44% from the 1929 level despite the fact that industrial activity was 11% higher! Consequently employers must intensify their efforts to reduce unit costs and, at the same time, be prepared to raise wages as never before. Correct incentives can help both of these needs at once.[1] The primary and universal reason for the installation of wage payment plans is today, as ever, to secure the lowering of unit total costs on the one hand, and to improve the earnings of the employees on the other. In every such plan which is a success, these two results are always secured and always go hand in hand.

While it is impossible to generalize in regard to the probable savings from a plan which is in contemplation, there are numerous records where labor costs have been cut, 25% to 50% by means of the installation work, and factory costs cut from 20% to 50%, by means of the incentive operation. Wages increase as production increases and production has been known to increase even up to 300%. Incentive plans are now available for all classes of labor. The range extends from unskilled laborers to foremen and other supervisory executives; from skilled mechanics such as toolmakers and die-cutters in a machine shop, to typists and bookkeepers in a business office. The greater the degree of skill required in doing the work, the greater the possibilities of improvement. This seemingly contradictory situation is true for the reason that unskilled employees are usually far better supervised than those that are possessed of higher skill. It is usually thought that the skilled mechanical operator can pretty much take care of himself, plan his work, develop his methods, and carry everything through to completion.

1 An industrial leader from the English Midlands said in 1941, "the prices paid for piece work, rather than the ebb and flow of war, determine the extent of England's output."

On the other hand, it is thought that the laborer or unskilled employee needs constant oversight in order to turn out a satisfactory amount of work of the desired quality.

Ample experience shows that a good wage payment plan properly installed will often increase the productivity of unskilled workers by 100%, machine operators 150%, all around mechanics 200%, and in cases of the higher skilled the percentage may run as high as 300. This shows the possibility of increasing production and at the same time securing lower unit costs.

Field for Incentives.—Another point of importance in this connection is the percentage of employees in a manufacturing organization that can be satisfactorily paid by some incentive plan. Surveys indicate that a number of industries have from 70% to 80% of their workers on this basis. These percentages are none too high for any manufacturing concern, and in fact, numerous cases are known where the total number of employees on the payroll, operating on an incentive plan, is as high as 90%. To mention the experience of a single plant, the Western Electric Company has long had 85% of its direct workers and 23% of its indirect workers on incentive plans.

Reward a Most Human Matter.—Industry has derived much of its progress from the inventions of mechanical devices and will continue to do so; but since the turn of the present century, there has been another major contribution. We refer to the better use of existing devices through the more studied organization and control of human forces. Among these human forces so far as industry is concerned are: (a) the need and hope of material possession, (b) the expenditure of human effort to that end; and (c) the reward roughly in proportion to the efficiency of the effort. We may divide these forces into two groups: on one side the urge for and the assurance of reward, and on the other side the work necessary to bring about fulfillment. Incentive and service under free institutions are equivalent and inseparable.

Any form of remuneration or profits constitutes some incentive to work. The relation between service and reward has, however, become less direct and less immediate. It has, therefore, become desirable to arrange plans by which a more definite and efficient work-wage contract may be secured. Extra-financial incentive plans, as they have come to be called, include all remuneration plans which provide money inducements above base time wages for the accomplishment of definite quantity-quality-economy standards. The latter standards or tasks are variously treated but in some form are

always prerequisite to the extra remuneration. Other incentives termed nonfinancial are also important but are treated here only as supporting measures. They rarely suffice as substitutes for extra-financial incentives.

Early Plans Misused.—Because of their psychological nature, extra-financial incentives were the first of the modern management "mechanisms" to receive nation-wide attention. As early as 1892, Jacob Schoenhof[2] had resurrected John Stuart Mill's old principle that high individual wages may mean cheap labor as a whole. In 1895, F. W. Taylor[3] presented much more than his incentive plan, but the discussion which followed narrowed down to that portion of the paper and disappointed him keenly. The paper did, however, turn the tide toward a higher wage policy. For the next twenty years numerous industrialists, many with meager qualifications, offered their services as consultants in "efficiency." The first thing such men did for clients was to install some new incentive plan. By neglecting the preliminary standardization they could make a temporary showing, collect sizable fees, and rush on to other clients before the real troubles had time to develop. Such "experts" sowed much bad seed and their better qualified successors had to suffer the results. Despite this, some of the early incentive plans were sound and properly applied. The worst we can say of the better pioneers is that they tried too many minor variations and too often attached their names to plans which were not sufficiently distinct to justify any new names. This divergence of practice gave us over a score of plans and hundreds of installation failures. The failures were not, however, confined to any one set of plans and were in the main due to the hasty application.

First Difficulties Began to Diminish.—In July, 1918, The Western Efficiency Society sent out a questionnaire on wages to 500

TABLE 9. PERCENTAGE OF COMPANY SUCCESS FOR EACH TYPE OF INCENTIVE

	Satisfactory		Unsatisfactory		No Experience	
1. Ordinary time and salary plans	43	+	57	+	0	= 100% etc.
2. Piece rate plans	54		3		43	
3. Straight commission plans	20		20		60	
4. Salary and commission plans	31		3		66	
5. Premium plans	9		20		71	
6. Bonus plans	42		9		49	
7. Profit sharing plans	5		16		79	

[2] Jacob Schoenhof, *The Economy of High Wages.*
[3] *A Piece Rate System,* A. S. M. E.

companies about Chicago. The questions and answers are indicated in Table 9.

1. All companies had used time rate plans and in 57% of the cases these were not satisfactory.
2. 57% had used piece rate plans, but of those 95% were satisfactory.
3. 40% had used straight commission plans of which half were and half were not satisfactory.
4. 34% had combined salary and commission plans, but 91% of those who had were satisfactory.
5. 29% had used premium plans and of those 70% were unsatisfactory.
6. 51% had used bonus plans and of those 82% were satisfactory.
7. 21% had used profit sharing plans but of those only 24% were satisfactory.

It is evident that there were then many companies which had never tried anything but time plans. The plan which had the greatest trial was piece rate and with that satisfaction was also greatest. Straight commission for sales has, however, always been difficult. Salesmen feel that the risk is too great. Where salary was combined with commission, the satisfaction was nearly as great as for straight piece rate in the factory. The record for premium plans was quite decisively against them, while that for bonus plans was even more decisively for them. Profit sharing plans had been little tried and less liked. Similar surveys made in 1922 and 1924 may be seen in J. D. Hackett's, *Labor Management.* •

Over Half of the Employees on Time Payment.—In 1926, the Sherman Corporation sent to American employers a questionnaire on incentives. Over 1,000 reports were secured, representing more than 500,000 employees. The percentages given in Table 10 for the three broad types of plans canvassed are based on the number of employees affected, not on the number of companies.

Steady Increase in Use of Incentives.—In 1927, the National Metal Trades[4] undertook a survey of 672 member companies. Of these 365 companies, or 54.3% of all companies reporting, use some extra-financial incentive plan for part of their employees, and it has been estimated that nearly 50.7% of all the employees, belonging to the 365 companies, are on such incentives. This leaves 307 companies, or 45.7% of all employees besides 26.8% of the above em-

[4] Committee on Industrial Relations, *Methods of Wage Payment.* The summary here given is by the courtesy of W. E. Odom, Director.

TABLE 10. DISTRIBUTION OF INCENTIVE PLANS

	Per Cent of Employees in Plants Surveyed		
	Straight Time	Piece Rate	Premium or Bonus
General Average (all industries surveyed)	61	31	8
1. Agricultural implements	56	42	2
2. Automotive products	17	18	65
3. Bakeries—bread, cake, biscuit	63	30	7
4. Beverages	81	14	5
5. Building materials—brick, clay products, stone etc.	60	37	3
6. Candy and confectionery	65	32	3
7. Chemical and pharmaceutical	65	18	17
8. Clothing—men's and women's garments, etc.	32	67	1
9. Construction—buildings and public works	100	—	—
10. Dental equipment	52	5	43
11. Dairy products	96	4	—
12. Electrical products and radio	60	39	1
13. Flour and feed	90	5	5
14. Food products	82	10	8
15. Foundries—cast iron, malleable steel, and alloy	55	41	4
16. Furniture	57	38	5
17. Glassware and pottery	55	32	13
18. Hardware, toys, and specialties	46	45	9
19. Ice and cold storage	95	5	—
20. Jewelry, watches, clocks, and optical instruments	41	54	5
21. Knitwear, hosiery, underwear, etc.	29	67	4
22. Lumber, millwork, and wood products	79	6	15
23. Machinery	68	18	14
24. Meat packing—beef, pork, etc.	88	12	—
25. * Metals and metal products	49	27	24
26. Musical instruments	18	75	7
27. Oils, paints, inks, etc.	81	18	1
28. Paper mills	81	7	12
29. Printing, publishing, and lithographing	69	7	24
30. Power plant equipment	75	18	7
31. Public utilities—water, gas, electricity, etc.	100	—	—
32. Railway equipment—cars, locomotives, etc.	31	68	1
33. Rubber tires and products	20	80	—
34. Shipbuilding	90	10	—
35. Shoes	22	76	2
36. Stoves, furnaces, and radiators	49	46	5
37. Tanneries	69	24	7
38. Textiles—cotton, silk, rayon, wool, etc.	46	33	21
39. Tobacco products	29	71	—
40. Miscellaneous	70	30	—

* Steel included. In steel industry, 10.4% employees of mills reporting, on tonnage basis.

ployees, on the straight time basis, that is, 27.5% of National Metal Trades Association employees were on extra-financial incentives. Further analysis is restricted to the latter group (Table 11). A large company may have not only several types of incentives but several variations of the same types. One company reported that its 900 employees were paid as follows: 40.8% on the time plan, 35% on a modified Emerson plan, 17.4% on a special group bonus plan, 6.8% on a quality bonus plan, and all on an attendance bonus plan. For the whole group there were 247 piece rate applications, 104 premium,

TABLE 11. RECORD OF EARLY INCENTIVES

According to the returns of 245 members,

173—or approximately 70% are still using the incentive plan originally adopted.

48—or approximately 20% changed or modified the original plan to the incentive now being used, while

24—or approximately 10% at one time used an incentive plan but abandoned it in favor of the straight time or day work plan of payment.

Of the 72 incentive plans changed or abandoned,

24 were Ordinary Piece Work Plans replaced as follows:
- 7—by Halsey Sharing Plans
- 4—by 100% Sharing Plans
- 3—by Group Bonus Plans
- 2—by Task and Bonus Plans
- 2—by Bedaux Point System
- 6—by Straight Time or Day Rate Plan

22 were Bonus Plans replaced as follows:
- 12—by Piece Rate Plans
- 1—by Differential Piece Rate Plan
- 1—by Efficiency Scale Bonus Plan
- 8—by Straight Time or Day Rate Plans

20 were Premium Plans replaced as follows:
- 6—by Piece Rate Plans
- 2—by Group Bonus Plans
- 2—by Bedaux Point System
- 10—by Straight Time or Day Rate Plans

4 were Group Bonus Plans replaced as follows:
- 3—by Individual Piece Rate Plans
- 1—by Individual Premium Plan

1 Group Premium replaced by Individual Premium Plan

1 Rowan Plan replaced by Halsey Sharing Plan

53 bonus, 33 group bonus, and 52 miscellaneous applications. It is significant that there were as many piece rate plans as all the other extra-financial incentive plans combined.[5]

[5] See *Factory*, September, 1930, and March, 1931.

Always Some Shifting from One Plan to Another.—Although 70% of the companies in the last-mentioned survey continued to use their original plans, some 20% of the companies had shifted from their original plans to others. Some of this change, no doubt, was in the way of improved modifications, but some was mere change. Such floundering is usually increased in time of depression. For instance, in 1930 a survey of 149 manufacturers showed that:

22 had changed from piece rate to bonus.
18 indicated that they were about to do the same.
21 had changed from time rate to piece rate.
4 indicated that they were about to do the same.
6 had changed from bonus to piece rate.
6 indicated that they were about to modify their bonus plans.

Depression to Recession.—From 1930 to 1937 the industries of the United States suffered both fire and plague—fire, in that markets and job were lost; plague, in that semiradical experiments became epidemic. Some of the latter affected and will continue to affect wages. For instance, wages and hours were limited by law, collective bargaining was made mandatory, company unions were forced aside, new vertical unions were born and bred to aggression, and the whole concept of industrial relations was altered. At the same time taxes, old and new, increased tremendously but not sufficiently to balance governmental budgets.

More specifically, hours were decreased 20% relative to those of 1929, and money wages simultaneously increased 20% throughout all industry in the United States. In manufacturing industries alone and since 1933 the wage rates increased about 60% and these advances in money wages exceeded the advances in commodity prices.[6] In the fall of 1937 the real wage of factory labor was 37% above that of 1929, but this had shrunk considerably by the end of 1937; in fact, unemployment had increased again to an alarming degree. Employers began working overtime to adjust themselves and their policies to new labor requirements.

Confusion Regarding Incentives.—Publicity regarding incentives, frequently inexact, was particularly confused during these depression years. First the N. R. A. made the low efficiency portion of straight piece rate illegal and many such arrangements had to be suspended until the N. R. A. was itself pronounced illegal. As a whole the use of incentives is believed to have increased during that time because incentives were needed to keep costs down. Then the

6 Production per man-hour had only increased 4.1% on the average.

automotive industry stopped calling some of its line work "gang piece rate" and the popular magazines made it appear that all industry was going over to day work! There was certainly some shift away from piece rate, but it was mostly from gang piece rate. The editors should have explained that when the rate of production is controlled by a mechanical conveyor, it is immaterial whether the method of payment be called piece rate or day rate, the character of such work is hybrid and its payment merely needs a new name, such as "belt-paced" or "mechanically-paced" rate.

Comparison of Surveys.—	1922 Gemill	1924 N.I.C.B.	1932 Jucius*	1935 N.I.C.B.
Percentage of Employees on Time Wages.	53.5	56.1	29.4	56.3
Percentage of Employees on Incentives...	46.5	43.9	70.6	43.7

* The Jucius Survey covered only the most progressive companies.

These figures cannot be taken as exact, but if they have any significance they contradict the claims that there was a general trend away from incentives. The survey printed in *Factory*, October, 1937, showed that:

52.42% of the 133 plants were increasing the use of incentives.
44.35% of the 133 plants were making no change.
4.00% of the 133 plants were decreasing the use of incentives.

How One Large Company Has Developed Incentives.—The history of incentives for this company may not be typical but it is interesting and a good example of alert management.

1890-1902 They used straight piece rates without derived tasks (also some contract work).
1902-1912 They used Halsey premium (also some gang piece rate).
1912-1920 They used the original Gantt plan.
1918- * They modified this to their so-called Standard Time plan (full time guarantee, small step bonus, and high piece rate, the last paid as 100% standard hours).

In 1924—46% of man-hours were on incentives
" 1926—50% " " " " " "
" 1932—72% " " " " " "

1928-1932 In addition, a sharing plan was adopted for 1,200 key men. It was based on a budget for savings. Others received a share based on a budget for profits. Executives received a share based on company earnings in excess of 6% return on investment.

In the meantime the depression had forced the company to reduce all salaries:

Those below $200 per month to 80% of base
" over " " " " 70% " "

*Same today except step bonus was eliminated April 1, 1937.

One percent was to be restored for every $40,000 increase in earnings above zero, based on an average of three months.

1936 The last-named restoration was applied to all employees. When the monthly net income (three-month average) reached $600,000 all received base pay for the next three months. Thereafter, 1% was added per month for each successive $60,000 gain in net income. When the average base payroll passed $5,000,000 the gains in net income were prorated in the same proportion as the basis for further increases.[7]

1941 85% of all nonsalary employees are on some regular extra-financial incentive plan. This includes 70% of the indirect producers. The latter figure should be a challenge to other managements!

Some Employer Experiments.—During the recession some employers turned to the cost-of-living index as a means of continuous rate correction. Then there were some experiments in the direction of improved profit sharing, attempts to provide a lump financial incentive for all company employees *en masse*. Two well-known companies did this by means of a monthly bonus based on a three months' sliding scale of production gaged relative to a standard amount. This brings profit sharing into some relation to current production, but it hardly takes the place of a true production incentive and is probably not so intended.

Other experiments were made in the direction of yearly salary and constant labor cost. The Geo. A. Hormel & Company of Austin, Minn., packers of pork, devised about March, 1936, a "Straight Time" plan. The weekly volume of work fluctuated badly and required much hiring and firing. By the new plan the employer pays a constant rate per week which amounts to guaranteed all year salary. The starting time per day is fixed but the employees may go home when they finish the work in hand. If the hours are less than 36 per week, they must be made up when the schedule needs more than 36 hours per week. Thus a debit-credit account is kept up but not carried beyond a three-year reckoning.

A somewhat similar plan is that the Nunn-Bush Shoe Company of Milwaukee. The employee is guaranteed his total annual earning through 52 equal weekly payments. The amount per week is not guaranteed but varies only if and as the labor cost varies and that has been nearly constant. In other words, it is a yearly salary adjusted to keep labor cost at a constant percentage of the sales dollar. Wages rise and fall with the price level as in the Fisher scheme. The incentive lies in the hope of a labor-cost saving which is returned as a dividend at the end of each year, or negatively in the fear of a reduction under reverse conditions.[8]

7 See A. M. A. Personnel Series No. 30.
8 For Sears, Roebuck plan, see *Factory*, January, 1939.

Point or man-minute plans installed by Bedaux, and others, were put on the spot[9] and have been improved thereby. Even the best installations of this kind were being put on the defensive.

Elsewhere the continuance and extension of incentives went on much as it did in 1929. In fact, there were definite indications of an increasing interest in incentives. The factors that are new are the status of unions and the soaring of costs.

Union Attitudes Toward Incentives.[10]—The piece rate plan carried over an association with rate cutting from the days of no standards. That evil goes with poor management regardless of the kind of incentive and should no longer be included as a characteristic of well-managed high piece rate. The latter is more generous to employees than other plans except some in its own class, the multiple piece rates and accelerating premium rates. Some employees never realize this but their leaders should know it and some do. At least piece rate, under its severally named varieties, has always been used more than all other plans taken together. Many unions have, therefore, accepted such piece rate especially during the prosperous portion of the business cycle, as a means of higher earning and we believe the intelligently led unions will usually continue to accept good piece rates for that reason. There will remain plenty of room for unions to bargain collectively on the relationship of rates and tasks. Sometimes all piece rates must be approved by the union. No doubt the substandard employee, union or nonunion, greatly dislikes any incentive, and no doubt the union officers who cater to such for increased membership also dislike incentives, threaten them during the membership drive, etc., but when asked, at negotiations, for other guarantee of a fair day's effort, they have no answer—make no interference. Some employers report that the unions do go into the matter of limits, agreeing to incentives provided average incentive earnings are 15%-30% above day earnings.[11] In other cases unions have asked to have a change from one incentive to another, to have straight piece rate expanded, to have all day work, etc. There seems to be no fixed policy other than to act expediently whatever the direction. Frequently this matter is never raised in negotiation. Nevertheless there is some reason to believe that certain labor leaders would like to eliminate all plans other than the simple time plan. With this in mind it may be well to explore the grounds for this attitude.

9 The A. F. of L. Report on Bedaux was published in the *American Federationist*, September, 1935. The newspaper publicity came in November, 1937.

10 Article by author published in S. A. M. Bulletin, March, 1937.

11 In August, 1941, a strike at a Crucible Steel Co. plant was settled by the company promising to arrange bonus plans whereby maintenance men could increase their earnings \$.10 to \$.15 per hour and crane men \$.06 to \$.09.

I. There is the fallacious, but depression-stimulated, "Lump of Labor" theory. This is believed by many of the unskilled and uneducated workers, probably by a few of their leaders. This theory ranges its believers definitely against all influences for efficient quantity production, and leads to restriction of output if not to sabotage. The "stretch-out" or "speed-up" of unscrupulous "engineers" has intensified this.

II. Collective bargaining, when it ignores minorities, is a leveling process. The individual is merged with his group and individual superiorities are frowned upon. Although any sound union should voluntarily raise its standard of proficiency at the bottom, it may, by the nature of things, involuntarily lower the standard at the top. Particularly during business recovery, when membership drives are intensive, it is likely that the net effect of leveling will be downward rather than upward.

The leader with membership uppermost in his mind may dislike an incentive in that it tends to show up and embarrass his less efficient members. Superior producers themselves may be restrained by this thought.

III. While a union leader is usually sincere in wanting to help his membership get higher wages, he may be embarrassed if some of his members get by themselves much more than the rank and file receive. If such individual variation leads to the loss of membership at the top, or to the refusal of desired members, the leader's aversion for incentives will become a fear of them. Coupled with this is the danger of employee preference for, and loyalty to, his employer rather than his union. In other words, if all employees in each job class were paid as well as the most efficient ones are paid through incentives, there might remain little service for the union to render.

IV. Since the very objective of an incentive is to incite the employee to do, through self-interest, just what the employer wants done—that is, to make cooperation automatic—there is under well-managed incentives little need for complaint and intercession. Where complaint and intercession constitute the life-blood of a union, as they so often do, it is evident that the incentive may seem to the leader as a threat to his own career and livelihood. The leader may really desire cooperation but he wants it through himself.

Thus there is sufficient reason for union *leaders* to oppose any incentive if they deem it expedient. Since 1937 some have been doing so. In such cases we think it is merely a change in relative strength, not a change in belief. Conversely, the employer may tire of the struggle and allow a change against his preference as a mat-

ter of strategy. If so, it is similarly a change in circumstances rather than a change in belief.

Incentives Needed by Employees.—On the more cheerful side we believe that most union members have welcomed, and in the long run will accept, the incentive as a means of higher earning and happier relations. Even with a more cooperative trend between labor and capital, we must go farther than ever in manufacturing economies. Should the working period be further reduced and the labor cost further increased, both of which are possible, it seems evident that industry would have to go much farther in mechanization as well as in productive efficiency. The direct incentive is only a part of management technique, but since Taylor it has been a vital part. Can the union leaders miss seeing this? Some of them were coming to see eye to eye with management from 1922 to 1929.[12] We hope more of them will do so again and we believe they will. It certainly behooves management to make every effort toward that end.

Better Shop Management Necessary.—To accomplish this management must do several things better than formerly. It must use more scientific methods in job standardization, that is, it must take the pains to improve job conditions and methods, rather than to rush through superficial time studies. It must stop rating the time study subject on "expert" guesses. It must obtain the consent of the employee for both the job study and the subsequent changes. It must make its plan of wage payment fair and simple. It must coordinate its own functions and win cooperation of employees, individually and collectively. Many employers have done all of this, but there are far too many who have not. Since fair and reliable tasks are prerequisite to any successful use of incentives, it may be well to be more specific concerning time and motion study. In this matter average practice has lagged way behind what is known to be good practice. The primary purpose itself is often subordinated to secondary purposes, that is, real methods-improvement is neglected in the hurry to fix "paper" standards. Briefly, all important jobs should be studied scientifically and slowly. The subject of the study should be made a partner in this research. The principles of correct motions should be known, or in other words, the analyst must be trained in motion study even when it is impractical to use the complete micromotion technique in deriving the task time. Elements must be as small as possible and the number of cycles finally timed must be enough to assure representative procedure. More than one subject

[12] At the A. F. of L. 1925 Convention in Atlantic City, organized labor committed itself to the specific productivity theory of wages.

should be studied in many cases. If the stop-watch is used, continuous readings must be taken to account for all intervals and preferably a trustworthy minimum time should be taken as the base time for each element. Allowances added to these minimum times must be adequate for the class of operations involved and for the normal working conditions.[13] American industrialists know how tó create greater wealth but they cannot go forward without certainty of lower total costs per unit and the incentive is one of the most effective prerequisites.

Survey of Present Use.—Most reliable data on extent to which wage incentives are now applied comes from a survey of 2,700 companies made by the National Industrial Conference Board.[14] These companies represent all kinds and sizes of business in the United States, and employ approximately 5,000,000 workers. Of these miscellaneous companies 51.7% employing 2,655,000 workers, use wage incentives. Among them are 900 manufacturing companies ranging in size from 100 to 10,000 workers. Of these manufacturing companies 75% use wage incentives. Again breaking down to the 313 companies which furnish more specific information, 60.3% of employees who are on some incentive plan, are on piece rate plans (48.7% as individuals and 11.6% in groups). Of employees, on some incentive, 30.9% are on various premium or bonus plans (17.7% as individuals and 13.2% in groups). The remaining 8.8% of those on incentive, are on "measured" day rate; no distinction between individual and group application was reported. Counting all employees, 376,833 in the 313 manufacturing companies, 61.6% are on some form of extra-financial incentive, against 38.2% on ordinary time rates and .2% unclassified. (See Table 12.)

TABLE 12. EXTENT OF WAGE INCENTIVES IN THE UNITED STATES, 1940

Type of Plan Used	Number of Employees on Plans	Per Cent of Those on Plans to All Employees	
1. Ordinary time rates	143,993	38.2	
2. Individual piece rates	112,977	37.2	
3. Group piece rates	27,005		
4. Individual premium or bonus	41,031	19.0	61.6*
5. Group premium or bonus	30,613		
6. "Measured" day rate	20,312	5.4	
7. Unclassified	902	.2	
Total	376,833	100.0	

*Collecting items 2 and 4—40.9% participate as individuals.
Collecting items 3 and 5—15.3% participate in groups.

13 See *Motion and Time Study*, by Allan Mogensen; *Motion and Time Study*, by Ralph M. Barnes; *Applied Motion Study*, by F. B. and L. M. Gilbreth.
14 Studies in Personnel Policy No. 19.

Further analysis of 265 of these 300 companies shows:

Number of Companies	Per Cent of Employees on Incentive
14	Less than 25
15	25–49
149	50–74
72	75–89
15	90 and over

Analysis of the 300 companies as to size shows:

Number of Companies	Number of Employees	Per Cent on Incentive
30	Less than 250	55.7
64	250– 499	61.8
96	500– 999	65.2
47	1,000–1,999	64.0
23	2,000–2,999	62.1
27	3,000–4,999	64.5
13	5,000 and over	54.2

From these analyses, it appears that *company size makes no material difference* as to use of incentives. A further fact is that there appears no tendency for any few particular plans to supplant the many plans that have been put into use.

Broad Advantage of Incentives.—In conclusion we will reiterate the one general advantage of all regular extra-financial incentive plans. We refer to the *automatic alignment of effort* with a *minimum of supervision,* and most of that *strictly impersonal.*

CHAPTER 3

SELECTION OF INCENTIVE PLANS

> It will be a good investment for management to examine its financial incentive plans critically at this time. . . . If the employees are dissatisfied with a given plan, then there is likely to be something wrong, either with the plan itself, its installation, or its administration. . . . Financial incentive plans have been applied successfully to all classes of positions in a company.—HAROLD BERGEN.

Company Policy Regarding Wages.—It is difficult to set up any standard set of policies for companies in general but A. L. Kress has ventured to do this in outline as follows:[1]

1. General wage level should be at least equal to prevailing wage level for similar work in the community.
2. Wage for each job or operation in the plant should be determined, relatively with other jobs, with due regard for skill, responsibility, experience, physical demands and hazards.
3. Individual or group effort should be rewarded wherever possible, through use of an incentive method of wage payment, where such a plan can be properly applied.
4. Fair standards of performance should be set which can be reasonably and consistently attained.
5. Full information should be given to any employee regarding the wage payment policy or plan. Management should discuss with employees, whenever requested, the setting of standards, the fixing of occupational wages, the computation of earnings, or the standards themselves.
6. A reasonable normal work week should be adopted (with provisions to meet seasonal demand or emergencies, if necessary).
7. Employees should be compensated for waiting time due to reasons beyond their control, under piece work or bonus.
8. Complaints arising from the operation of wage payment plan should be investigated promptly and adjusted in accordance with the facts.

[1] N. E. M. A. Industrial Relations Bulletin No. 19.

Considerations for Change in Policy.—Earnings may range anywhere between the necessary hiring rate per week and allotted amount of labor cost which the business can afford to pay per week, up to an unwarranted sacrifice of gross profits. What the company can afford to pay can only be determined by considering the whole economics of total cost as that is affected by volume. If it is assured that the use of a strong incentive will increase the efficiency of production, say 25%, then a fifth of the employees might be dismissed, or working hours might be shortened a fifth, or 25% more goods might be produced. The time and motion study that is done in preparation for incentives can be relied upon to reduce, in potentiality, labor cost per unit of product. The proper incentive then acts as an enforcement of this potential saving, and, in addition, achieves an increase in volume of production which brings a saving in overhead cost per unit of product and a net saving in total cost per unit. A reduction in selling price is thus possible, or if that is uncalled for, the gain from improved overhead distribution might go to plant improvement, plant extension, or to increased profits.

If these various outlets do not require all of the gains, then the company can afford to increase voluntarily its wage rates. Many companies have, through incentives and accompanying activities, been able to provide for all of these gains. Naturally this whole process depends upon volume and price of sales orders which a company can budget. This, in turn, depends on competitive conditions, stage of business cycle, impositions of government, etc. But whether a business needs *to increase volume* to keep up with orders, *or to decrease costs* to meet price competition, it can usually make further reductions in labor cost through time and motion study, and in overhead cost through incentives. In short, use of improved tasks and better incentives can be helpful in either prosperous or unprosperous times. Furthermore, there is no end to these potential gains. Strange as it may seem highly developed plants are as likely to find further gains as are poorly developed plants.

Making the Policy More Specific.—In the United States it is likely that every company will now have had some experience with one or more incentive plans and from that experience can set up its own list of risks it wishes to avoid and objectives it wishes to attain. An incentive plan is best only in the light of the conditions which it must fit. There are, however, a few principles which may be used for guidance. The first consideration must be the direction of change desired, consistent will all policies of the company. This may be met by having a management committee apply the Dennison

classification (Table 19) to the given conditions. The second consideration is the apportionment of weights to the fundamental interests which will assure each one its proper emphasis. There are three of these fundamental interests connected with every job: (a) quality of work, (b) quantity of work, and (c) economy in the use of materials. The relative importance of these fundamentals varies widely, and a requirement of a well-determined wage incentive is that it shall correctly reflect the relative importance of all three. As in job evaluation, the problems of quality, quantity, and waste can only be understood by thorough job study.[2] It is evident, therefore, that little should be expected of any incentive until job standardization and job evaluation have standardized all of these matters.

Quality Standards.—Specified tolerance with "go" and "no-go" gauges for machine shop practice is familiar to most of us, but we are not all so familiar with definite quality specifications and tests for other materials. In the silk industry, the proportion of certain imperfections which may be tolerated per inch of weave is now being standardized in plant laboratories. In chemical processes, where imperfection may be equally allowed on either side of a standard, plus and minus tolerances are set so that an operator exceeding the allowed error in either direction is graded a definite amount less than task. By the use of recording instruments, Robert Wolf has established such specifications as temperature, moisture content, pressure, etc., on wood-pulp cooking.[3] Wm. O. Lichtner has established elaborate written specifications for the mixing of colors, etc.

Waste of Material Standards.—In many industries, the value of the material used is greater than the value of the labor. In leather work, it is more important to secure the maximum number of units from a skin than to save too rigidly on labor. "For example, if the cost of a certain piece of leather is 10 times the labor cost of cutting it, it is in the interest of the management to reduce spoiled pieces even at a slight reduction in output. It is better to cut 10 pairs of shoes and spoil no leaher than it is to cut 15 pairs and spoil one." In the wood industry, C. M. Bigelow has established standards of waste on which bonuses may be paid inversely to the amount of such waste. In the film industry, waste of material and quality of product merge into a single problem.

Control Quality and Waste by Indirect Measures.—Unless quality or waste is extremely important, it is sufficient to enforce

2 L. P. Alford puts the relationship of task to incentive into three concise laws. See *Laws of Management Applied to Manufacturing.*

3 A. S. M. E. Transactions, 1918.

those standards by inspection and to make fulfilment of them a prerequisite to any quantity standard. This necessitates more attention to inspection than is usual for work done without a quantity incentive. The first reaction of a foreman to a quantity incentive is apprehension for quality. He knows that more quantity may easily be attained at the expense of quality. When inspection is well enforced, however, there need be no conflict between quantity and quality or quantity and waste. The most usual problem is to provide reasonable protection for quality and waste by inspection and at the same time put all possible emphasis on quantity. Strong inspection with definite specifications is, therefore, a necessary accompaniment of any quantity incentive. A supervisory incentive or a non-financial incentive may also do much toward the same end through general cooperation. In many cases it seems justifiable to spend somewhat less on direct quantity incentives and more on these indirect measures. The whole thought may be summed up in the general principle: determine the interests of management, specify them definitely, provide tests and checks, and then arrange incentive details so that the interests of the employees and management will coincide.

An Incentive Should Not be Expected to Stand Alone.—Broadly speaking, good management is in itself an incentive and without it no special incentive can be made worth while. A unified management in which the financial incentive is an inseparable part is the ideal. There are many degrees of good management and even the best managements have their relatively strong and weak points. It is safe to say that most managements are constantly improving and that improvement normally continues indefinitely. It is practical, therefore, to proceed with each phase of management, of which the incentive is one, and at the same time go over and over all other phases. The "one best way" and the so-called "ultimate standard" are, after all, but temporary concepts.

We are particularly familiar with policy on its negative side. We know we should not use a production incentive combined with poor job standards or poor control because employees will run away with earnings at the expense of quality. We know we should not use the group principle loosely to dodge clerical work. We do not always define objectives positively nor make extensive preparations before starting an incentive plan as we probably would before starting a sales campaign. We are prone to forget that the cost of good preplanning will be saved later. After an incentive is installed, the daily planning of work is equally important to its success. While an incentive plan should automatically promote all the various phases of

management control, it is irresponsible for management to neglect any one of the phases. This is particularly so with group incentives. If the hour or minute is used as the basis of figuring earnings, as it can be used even for piece work, weighted points may be made to assist all the way through. Such a unified system may be superior to one in which these measures function independently. Taylor, Gantt, and Emerson, all aimed in this direction, but pioneering often prevented attainment. Since then the best installations of the point plans have gone farther in this direction.

Essentials of a Good Incentive Plan.—By no means consider an incentive plan as a cure-all! It is not even a primary remedy for industrial ills, but a phase of control effective only after such primary measures as: correct processing, improved layout, job standardization, and evaluation have been thoroughly carried out. It is like oats for a horse; oats cannot change the breed, but can maintain the spirit. The simile is fortunate because in both cases overdoses as well as underdoses are disastrous.

It is impossible to set up a single set of ideals for all plans. Special conditions have special requirements and no one plan should be expected to meet opposing conditions. We can, however, outline the essential characteristics an incentive plan should possess for the ordinary manufacturing department:

1. It should be just to both employer and employee, increasing the mutuality of their desires. It should be positive, not unnecessarily punitive, and so operated as to promote confidence.
2. It should be strong both ways, that is, it should have a standardized task, preferably high, and a ~~generous reward~~. The latter should usually be in direct proportion to employee effort, preferably more than this for the highest production. One writer puts this aptly, "It should reflect an employee's contribution to his company's success."[4]
3. It should be unrestricted as to amount of earning, that is, the rate guaranteed against change until the job is changed.
4. It should be reasonably simple for an employee to figure, prompt, and clear in its relation to individual performance, as well as practical for shop procedure. Intelligent employees dislike to see excessive clerical work nearly as much as do employers. The time period over which efficiency is averaged should be short, not longer than a day.

[4] Taylor insisted that a successful plan should offer: (a) laborers, 30% to 60% more than class; (b) ordinary mechanics, 70% to 80% more than class; (c) skill, brains, close application and bodily exertion, as high as 100% or more than class.

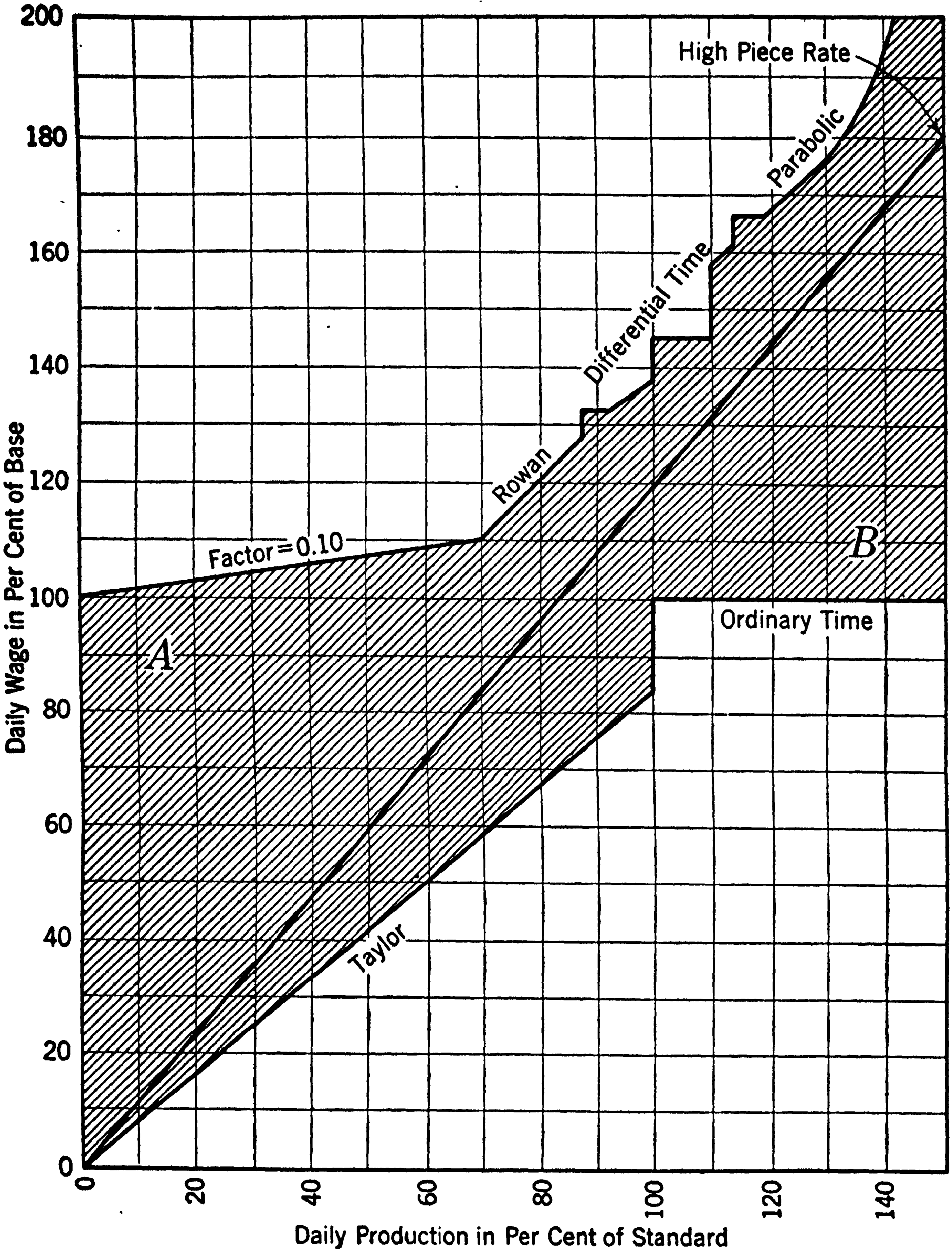


Figure 9. Over-All Limits of Earning Curves

5. It should be flexible and intimately related to other management controls.
6. It should automatically assist supervision, and when desired, be an aid to teamwork.
7. It should have employee support and in no respect be paternalistic.
8. It should have full managerial support in such matters as production, material and quality control, maintenance, and nonfinancial incentive.
9. It should not be used temporarily in busy seasons and dropped in dull times as a means of wage reduction.

It is impracticable to appraise each plan here relative to these specifications because so much depends upon the particular management concerned. This can be done, however, by any one management at the time of selection.

For a special set of specifications adapted to group applications, see Chapter 16.

Over-All Limits of Earning Curves.—Figure 9 shows the over-all limits of over two dozen earning curves subsequently charted in separate chapters. If we ignore the corner areas marked A and B, we will see that the average of all earnings is approximately a high piece rate. Corner A is of no consideration because its production is below the discharge point. Corner B is of no consideration because its low earning fails to hold the average production within its range. In other words, it is purely hypothetical and plans within it are without their intended effect. Similarly, plans not partly in the A or B corners, but near them, are for the same reasons weak. The first test of strength is, therefore, whether or not a plan is above or near the average already mentioned. This test may be more accurately made by comparing a plan in question with Figure 18.

Production a Response to Earning.—The single points of Figure 18 are also important when we consider the effect of a plan on a department or group. The whole earning curve is of interest to the individual employee, for he may be at different productions on different days; but the employer is most interested in the single point or narrow range of points at which a given plan will hold the average production day after day. In fact, no other point on the direct labor cost curve has anything to do with overhead cost in practice! This point varies between the plans and for a single plan in different installations, but it varies little from day to day for any one plan under one set of labor and managerial conditions. We will call such a point

the point of average response. Naturally, we desire this fairly high on the production scale and at first we may think we desire it fairly low on the earning scale.

Incentive Value Is the Important Thing in the Earning Curve.—As an incentive to the employee, the amount of earning is psychologically the independent variable and his production is a response. From this viewpoint, high earning is prerequisite to high production. An earning curve applies to single employees, and so far as any one employee is concerned, direct labor costs per unit and wages earned per unit are identical.

For the Department as a Whole, Consider the Total Cost Curve.—Fallacious thinking by employers about incentives is usually due to too much thought of *direct labor* unit cost and too little thought of *total* unit cost—that is, failure to consider a department as a whole. Selling price must include overhead as well as labor cost. Material cost is often independent of efficiency. Therefore, total cost per unit is the only true criterion of company results. Total cost per unit is inclusive and in no way misleading. The fact that for a given overhead total costs per unit decrease as production increases is the foundation of the "philosophy" that low wages do not mean low final costs. Were it not for this overhead-volume relationship, the lowest earning curve would be the best plan.

Reduction of Labor Cost Is Independent of the Earning Curve.—We can truly combine higher individual earning and lower unit labor cost by eliminating waste labor through improvements in machinery, methods, or control. By this means we may eliminate motions, suboperations, or whole jobs and secure the same net results with fewer kilo-man-hours. We cannot, however, raise earnings and at the same time lower unit labor costs any other way! Employee assistance to this process may come as the result of an incentive, especially if it is a group application, but such a result is incidental and not an expectation. In comparing any two incentive plans, it can usually be ignored. An incentive plan is primarily an operating mechanism. Any piece rate plan has the same direct labor cost per unit for small and large productions, that is, production varies directly with wages. Such labor cost per unit cannot decrease as production increases! Any earning curve having a slope less than piece rate does give increasingly less per piece as production increases, but this kind of reduction in labor cost is also a reduction in wages per piece. The old way of paying a decreasing amount for higher productions and getting such productions by driving methods

is practically gone. By such means a fairly high daily earning was possible with a low unit labor cost. Unfortunately, writers state this in terms of labor cost reduction. Consequently, the part waste elimination plays independently of the incentive is not understood by some readers. They jump at the conclusion that wages can be lowered per piece on existing conditions.

Comparison of Incentive Plans by Their Total Costs.—In comparing one incentive plan with another, we must consider the job standards as already improved and fixed. In these circumstances it is a flat contradiction to speak of lowering labor costs simultaneously with raising wages; they are practically one and the same. If we say total costs, there is no contradiction. Overhead is affected very little, usually not at all by the installation of a strong incentive as compared with a weak incentive. There are sufficient decreases to offset any minor increases in overhead. In fact, it is unnecessary to compare extreme plans to illustrate this princple. Let us take one plan which is very generous to the employee such as high piece rate plan and compare it with a fairly generous one such as Emerson efficiency bonus plan. We may assume within probability that the former is capable of raising and holding the average productive response of employees around 114% of high task, and that the latter is capable of raising and holding the average productive response of employees around 95% of high task.

From Figure 10 and Table 13, it is evident that the labor cost per unit is lower for the Emerson plan throughout the higher production efficiencies. If direct labor were the only consideration, there would be no purpose in considering the high piece rate for an instant. When we consider a department as a whole, however, we must admit that, other things being equal, average production is sure to be higher under that sharper-sloped earning curve. Therefore, it is only a matter of enough additional response to reach a considerably lower total cost, despite the higher labor cost. Which is the deciding factor? The total cost, of course, since it is inclusive of the other and also of overhead, both of which must be paid for by the sales price per unit. For the exact responses assumed above, the department under the high piece rate plan will have a higher labor cost per unit, \$.20, than under the Emerson plan, \$.19, but the former will have a total cost per unit of \$.47, and the latter will have a total cost per unit of \$.49. That is, the superior force of the high piece rate pulls the average response point to 114% efficiency which locates the resulting total cost at the lower part of the higher curve.

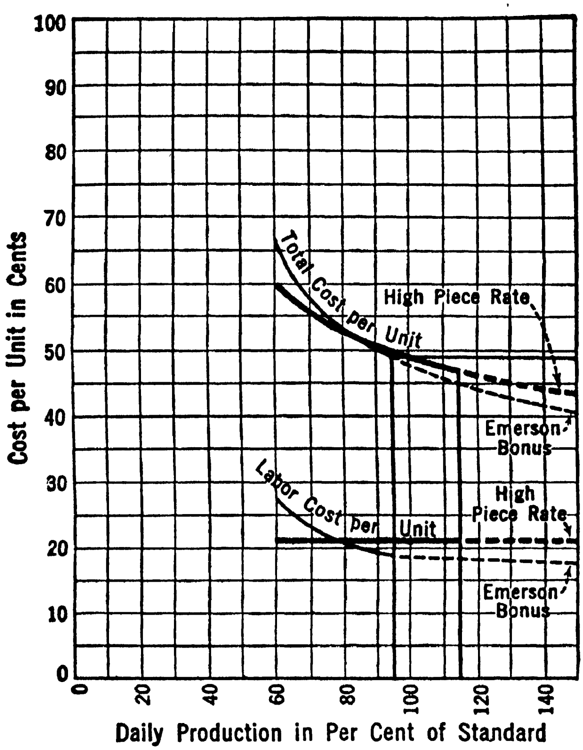


Figure 10. Cost Comparison of Very Generous Plan with Fairly Generous Plan

TABLE 13. COST COMPARISONS FOR TWO PLANS

	Average Production Response	Labor Cost per Unit	Total Cost per Unit
Emerson Bonus	95%	\$.19 (lower)	\$.49
High Piece Rate	114%	.20	.47 (lower)

Correct Principle.—Stated as an economic principle, this would be: When one incentive plan succeeds in holding the average production response at a higher efficiency than another incentive plan, the nearly constant overhead is distributed over more units and the overhead per unit is reduced. Consequently, the total costs per unit between two such plans may be: (a) equal despite different direct labor costs per unit, or (b) less in the case of the one having the greater direct labor cost per unit.

Taylor stressed this principle in 1895:

"The employers can well afford to pay higher wages per piece even permanently, provided each man and machine in the establishment turns out a proportionately larger amount of work.

"The truth of the latter statement arises from the well-recognized fact that, in most lines of manufacture, the indirect expenses equal or exceed the wages paid directly to the workmen, and that these expenses, remain approximately constant, whether the output of the establishment is great or small.

"From this it follows that it is always cheaper to pay higher wages to the workmen when the output is proportionately increased; the diminution in the indirect portion of the cost per piece being greater than the increase in wages. Many manufacturers, in considering the cost of production, fail to realize the effect that the volume of output has on the cost. They lose sight of the fact that taxes, insurance, depreciation, rent, interest, salaries, office expenses, miscellaneous labor, sales expenses, and frequently the cost of power (which in the aggregate amount to as much as wages paid to workmen), remain about the same whether the output of the establishment is great or small."

Were it not for this principle, there would be no incentives other than day rates and those would always be as low as possible. The principle has given rise to the many incentive experiments and, in truth, embodies the very essence of the incentive idea. There is no more important truth in the wage question of today.

Comparison of Total Cost Curves.—The chart shown in Figure 11 is simply an enlarged assembly of the total cost curves accompanying the two dozen earning curves. We have arbitrarily taken $.50 as a limit or maximum for total cost per piece and indicated it by a heavy line. Following across this line we may observe that the Taylor plan gives this at 70% production. This would be desirable were it not for the danger to turnover and poor morale. The basic piece rate plan gives this at 80% and the Merrick plan at 82%. They are both capable of holding the average response above these points

and are worthy of consideration. The Merrick plan requires higher production averages than the basic piece rate plan to make further reductions, but, due to its step at task, it is sure to hold the average response beyond where the basic piece rate plan will hold it. The Merrick plan can, therefore, give a lower total cost. In other words, the basic piece rate plan will begin to fail and drop out of consideration before the Merrick plan. We mean, in general, that the higher production portion of some plans becomes wholly academic and might as well be left blank. Where this occurs is difficult to say,

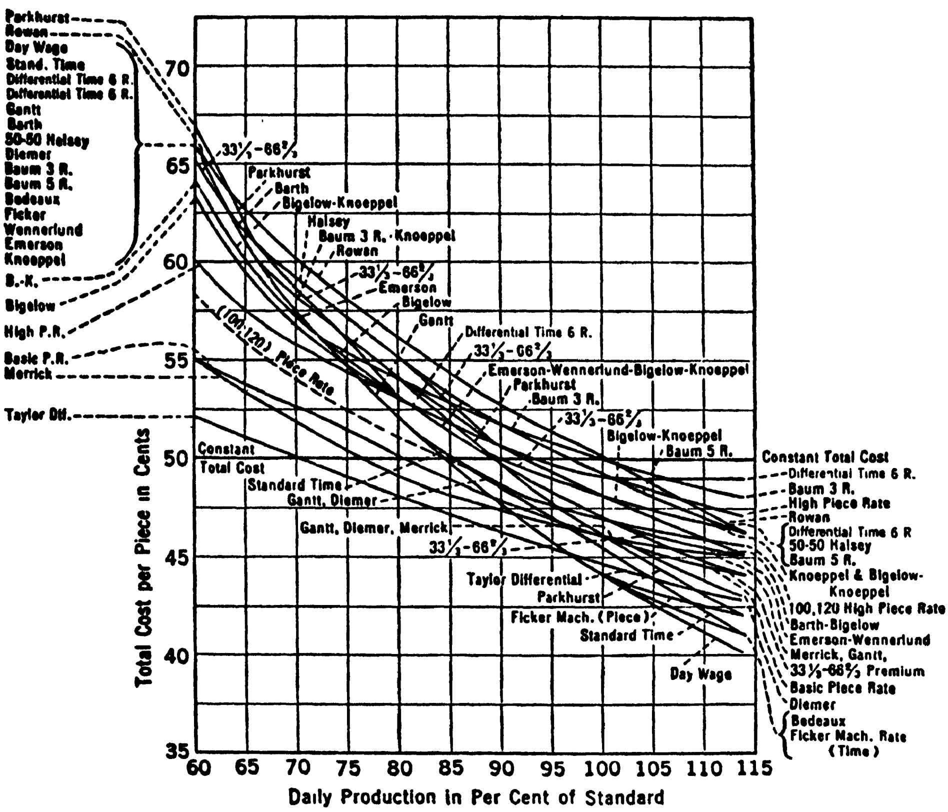


Figure 11. Total Cost per Piece of Twenty-Five Plans

but it does happen eventually for all plans and must be kept in mind. For the sake of illustration, let us assume that the basic piece rate plan is incapable of holding average response higher than 90% task at which the total cost per unit is \$.48; then tracing along the \$.48 cost line we find that the Merrick plan crosses it at 93% task. From there on the Merrick plan, total cost would be less than that of the basic piece rate plan by failure of the latter to deliver its cost on the average. The Merrick plan is certainly capable of holding to 100%

task, due to its step and probably to 110–120%, due to its sharp slope.

Again taking up the $.50 cost line, we note that the day rate plan crosses it at 84% task. This means nothing, as a base day rate is well known to fail long before this amount of production is reached. The day rate curve is, therefore, out of the comparison for high productions. What we have just said of the Merrick plan holds for the Gantt plan. The Diemer plan can be expected to hold the average response at 100% task on account of its step, but it cannot be expected to hold beyond because its slope is below that of the corresponding piece rate. Hence, the Diemer plan drops out of the running for productions above 100% task despite its apparent lower costs. The (33⅓–66⅔) sharing plan and the empiric plans cross the $.50 line at 89% task and can surely hold the average response that high although some of them are likely to fail soon after. Of the empiric plans those which include bonus steps at high task should hold to task, but the Wennerlund plan alone has a sharp enough slope to hold much beyond. The Parkhurst plan—class #2—has an apparent low total cost per unit but, since its slope indicates an earlier failure, that is meaningless. Along the $.50 cost line we next find the Barth, Baum 5 rate, and high piece rate plans. The first is beginning to have a low slope and may not be depended upon. The second has steps and may be depended upon. The third has no step but does have a sharp slope which may be relied upon for some further gain, but this is never so sure as a step.

We have now worked over to a high production range. Plans without either sharp slope or steps cannot hold the average response in this range. We must, therefore, eliminate the Rowan plan. The differential time plans and Baum 3 rate plan at 97% task and 100% task, respectively, can probably deliver their costs on account of steps. The Halsey (50–50) sharing plan, also crossing at 97% of task cannot be counted upon because of its low earning slope. A similar analysis may be made by taking any two vertical or production lines such as 90% and 110% of task. When this is done, it will be seen that some of the apparently expensive plans at 90% are much cheaper than the others at 110% of task. The others simply cannot fulfil their promises on the average.

Only a Narrow Range of Points Count on Total Cost Curves. —We may now conclude that only a single production point, in practice a narrow range of production points, are of consequence for any plan. When comparisons of total costs are made without regard to this, they are academic only. To ascertain these average response

points for the plans is difficult because of the local variables which may affect them, but the principle must not be ignored. Day wages look cheap and the differential time plans look expensive, but it would be ridiculous to expect the former to hold the average response of a whole department to a high production and it should by now be equally clear that well-managed step plans can do so. If a careful estimate is made based on experience and a reasonable average response point assumed for each plan being considered, then and only then may we determine which one will give the lowest total cost per piece of product.

Constant Total Cost as a Criterion.—The fact that piece rate gives a constant direct labor cost is well known and is used to test the labor cost of other plans. We are less likely to take the next step in thinking, that is, that total cost per piece cannot be constant for piece rate. As long as this item grows less and less with advancing production, we do not worry. By reverse thought, we should realize that for less and less production, total cost per piece goes up. This is, in fact, what makes lower and lower production so increasingly expensive. It is not the direct labor cost under piece rate, because that is constant. We become used to unavoidable conditions even when they are undesirable and it is often unavoidable to pay high wages for some low production. We do that all the time with ordinary time rates and with guaranteed day rates connected with otherwise strong plans. Now, if we are paying above the maximum total cost per piece, $.50 line in Figure 11, to inefficient operators, we will certainly welcome a strong incentive which will so hold the average response that its total cost per piece can be under this maximum. The maximum total cost per piece simply means the limit we can pay and derive a desired profit between it and the unit selling price.

Setting Up the Criterion.—From the foregoing paragraphs it is evident that this total cost per piece is the thing to which we must give major consideration, not direct labor cost per piece. If we recognize that and the possibility of lessening the overhead per unit charge as average production increases, we will not find it unreasonable to confine management gains to this overhead reduction or lowered total cost per unit and concede all the saving in wages to employees, that is, give a piece rate. Now for the sake of a criterion or a limiting gauge of what we might be able to pay in making the labor incentive most strong, let us assume a willingness to leave the total cost per piece constant throughout all productions. We grant that this has its impracticalities because we are never sure that overhead

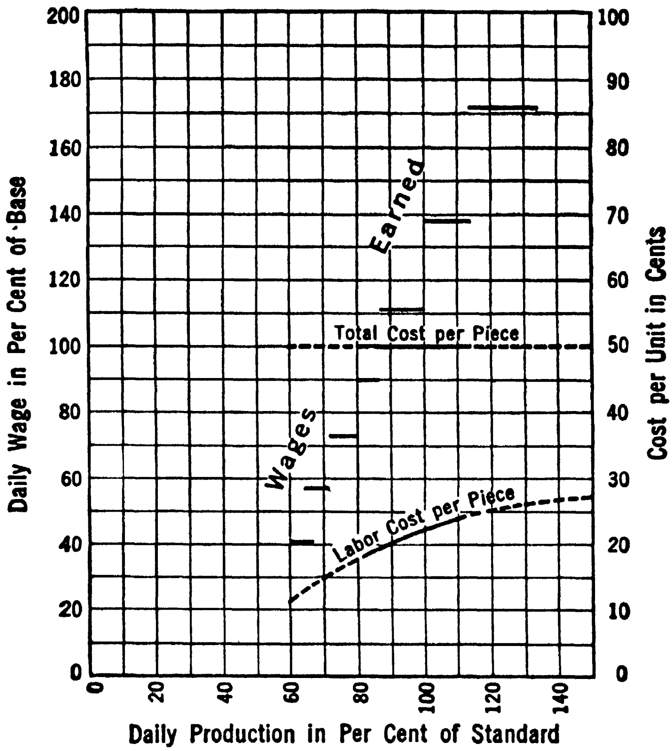


Figure 12. Constant Total Cost Wage Plan

TABLE 14. CONSTANT TOTAL COST PLAN DATA

#1 Per Cent of Production H_s/H_a	#2 Per Cent of Total to Base Wage for Full Day $E/H_a R_h$	#3 Total Daily Wage in Dollars E	#4 Number Pieces per Day	#5 Time Saved per 8-Hr. Task in Hours $H_s - H_a$	#6 Labor Cost per Piece in Dollars	#7 Total Cost per Piece in Dollars
60	41	1.58	14.4	− 5.3	.11	.50
66	58	2.24	16.0	− 4.0	.14	.50
73	73	2.80	17.5	− 3.0	.16	.50
80	90	3.46	19.2	− 2.0	.18	.50
89	111	4.28	21.4	− 1.0	.20	.50
100	138	5.28	24.0	0.	.22	.50
114	172	6.58	27.4	1.0	.24	.50
133	218	8.32	32.0	2.0	.26	.50
145	245	9.39	34.8	2.5	.27	.50

will not "pop up" higher than we thought in advance. Nevertheless, let us do this on paper.

Filling out the last column #7 of Table 14, we will put down the total cost per unit for all productions, in our case $.50. Then taking the amounts for overhead and material, in our case from Table 18, we reverse the usual process and subtract them to derive the labor costs per unit. These we place in column #6. Columns #5 and #4 are the same for all plans, as is also #1. The odd efficiencies are used in order to express the hours saved or lost per 8-hour task in even numbers. We derive column #3 by multiplying #6 by #4. This also is the reverse of usual procedure. Finally, we divide each value in column #3 by the base daily wage, in our case $3.84, and arrive at column #2. This figure is based on an hourly rate of $.48. We may now plot the earning curve of this "upper limit" wage plan between columns #1 and #2, the labor cost per unit curve from #6 and the total cost per unit curve from #7. From the resulting curves (Figure 12) we note that by keeping the total cost per piece constant we must give less and less per piece as average production grows less. The direct labor cost is, therefore, opposite to usual practice. Inefficient employees would, of course, quit their jobs rather than take the equivalent of their low production so that the left part of the curves are academic. As the earning curve is very low for low productions and high for high productions, the earning curve slope is sharper than that of other plans, except old-fashioned piece rate, and located through the 85% point of task at base day wages. This is, of course, on a higher task than that of the old-fashioned or "too good to be true" piece rate.

While a nearly straight line might be drawn through these earning points, it is infinitely better to use steps for any high wage plan. It necessitates special effort from zone to zone and steadies as well as increases response. This plan, when made to fit a given case, will show the limit of what we can afford to pay in direct labor at all individual production efficiencies in order to assure the very highest average production for a given total cost per piece limit. The method might even be used for actual payment if a company dared to stop all "charity" to low producers! It would not be paying as high per piece in total cost as it has always paid many low producers.

Check on Labor Costs.—It is startling to compare this extreme labor cost curve with the labor cost curve at the opposite extreme, that of the day rate plan. The enormous difference in amounts per piece at low production is misleading, however, because in the constant total cost plan the low-production labor cost would not ma-

terialize for many employees or very long for any. The little that might occur would be negligible when averaged in with the many lower labor cost individuals. Under day wages the left part of the labor cost curve does materialize for many individuals, frequently for long periods and without any very low labor cost individuals to bring up the average. In other words, there is a compensating feature about this proposal in that the average response would necessarily be high enough to save the cost through greater distribution of overhead per unit.

Exception to Constant Overhead.—In admitting the impracticability of the above as an actual plan on account of unreliable budgeting, and labor mass-thinking, we may also point out that there is one case in which overhead is likely to increase due to incentives. There is a growing tendency to pay some kind of incentive to every one, from foreman on up. When this is done, the overhead will be affected by the new installation and the overhead per piece may not materially go down as production increases. On the other hand, we doubt if such indirect incentives are likely to be of sufficient magnitude to break the general rule and that the total cost per piece will still be lower by paying a reasonably higher labor cost per piece. There are few situations where sound economics is so completely set aside by social considerations as in this matter of compensating inefficient producers.

Relative Range of Earning and Cost Variation.—Table 15 compares the extreme range of wages with the extreme range of total costs for all the plans charted.

TABLE 15. COMPARISON OF THE VARIATIONS IN EARNING AND TOTAL COST

Based on $.50 as standard total cost per piece

Day Average Production in % of Standard	Day Wage in % of Base Range between Extremes	Difference	Total Cost per Piece. Range in Cents (See Fig. 11)	Total Cost per Piece. Range in % of Ave.	Difference
60	50–102	52	52–67	104–134	30
70	58–111	53	50–60	100–120	20
80	67–122	55	48–56	96–112	16
90	75–132	57	46–53	92–106	14
100	83–145	62	44–50	88–100	12
110	100–159	59	41–49	82– 98	16

At 100% production, the lowest wage plan offers 83% of the basic day wage while the high extreme plan offers 145%, yet there is only a 12% difference in the total cost per unit at this point as

compared with a 55% of standard difference in wages. This is a demonstration of how incentives may vary greatly without making the same degree of variation in total unit cost. Actually the degree for the latter is much less because many of the plans are not effective throughout the higher productions.

Table 16 indicates the average production efficiencies which wage plans must hold for the plant as a whole in order to obtain the total cost levels of \$.65, \$.60, \$.55, \$.50, and \$.45, respectively.

TABLE 16. AVERAGE PRODUCTION EFFICIENCIES*

Total Cost per Piece	\$.65	\$.60	\$.55	\$.50	\$.45	
Parabolic Premium	–	–	–	**90**	**120**	
Taylor Differential	–	–	–	**70**	**97**	(Will hold beyond)
Merrick Differential Piece	–	–	**60**	**76**	114	
Basic Piece and New Haynes	–	–	**60**	**80**	106	
Bedaux	**61**	**66**	**75**	**84**	**97**	(Control adds much)
Ficker Piece	**61**	**66**	**75**	**84**	**97**	(Incentive acts late)
Ficker Time	**61**	66	75	84	97	
Time	**61**	66	75	84	97	
Gantt Task and Bonus	**61**	**66**	**75**	**85**	**114**	
Diemer	**61**	**66**	**75**	**85**	105	
Standard Time	**61**	**66**	**75**	**86**	**102**	
Wennerlund	**61**	**66**	**75**	**89**	**114**	
Knoeppel	**61**	**66**	**77**	**89**	–	(Never reaches lower costs)
Emerson	**61**	**66**	**75**	**89**	114	
Bigelow	**61**	**66**	**75**	**89**	114	
Parkhurst	**62**	**68**	**78**	**89**	103	(Parkhurst claims 92–96% average)
33⅓–66⅔ Sharing	**60**	**68**	**78**	**89**	109	
Barth Premium	**60**	**68**	80	92	114	
Bigelow-Knoeppel	**60**	**65**	**77**	**92**	–	(Never reaches lower costs)
Differential Time 6 Rate	**61**	**66**	**75**	**94**	–	(Never reaches lower costs)
High Piece	–	**60**	**73**	**94**	–	(Never reaches lower costs)
Baum 5 Rate	**61**	**66**	**75**	**94**	–	(Never reaches lower costs)
Differential Time 8 Rate	**61**	**66**	**78**	**97**	–	(Never reaches lower costs)
Halsey (50–50) Premium	**61**	**69**	**80**	97	–	(Never reaches lower costs)
Baum 3 Rate	**61**	**66**	**78**	**100**	–	(Never reaches lower costs)
Rowan Premium	**62**	**70**	**83**	100	–	(Never reaches lower costs)

* The efficiencies given in *light* type are the ones considered outside the probable attainment of the plans. This division is speculative and may not be accurate. The order is merely according to the average production they would have to have to hold total cost per piece down to \$.50.

Estimating Response to Bonus Plans.—After setting a standard task, the possible percentage of increase in production may be figured by estimating the actual time and then using the formula,[5]

$$\text{Increase in Production} = \frac{\text{Actual time} - \text{Standard time}}{\text{Standard time}} \times 100$$

If the actual time represents average performance or can be made representative by many applications of the formula, then the result-

[5] W. O. Lichtner, *Time Study and Job Analysis.*

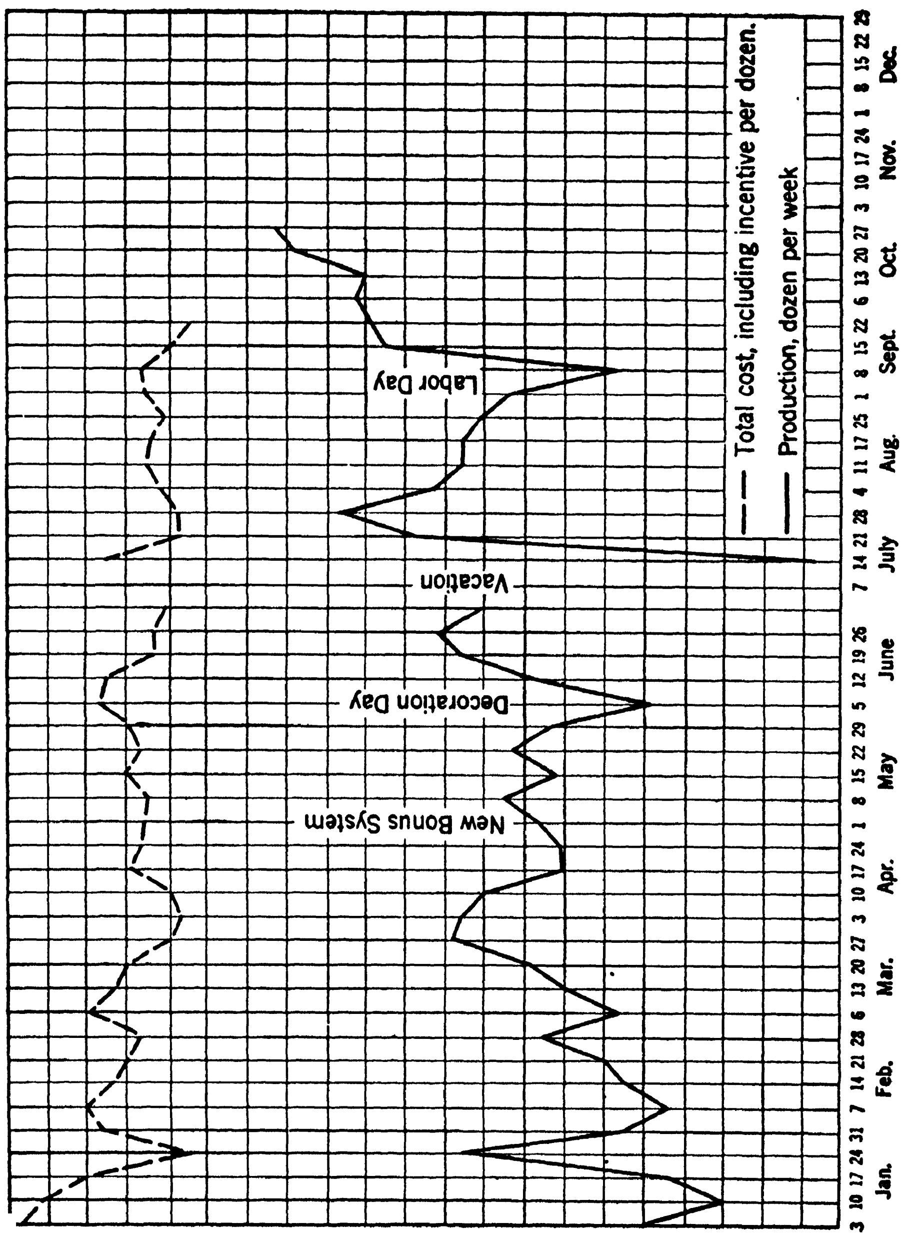


Figure 13. Total Cost-Production Chart

ing percentages will indicate the probable increase. It is rare, however, to find a department where the range of performance is not widely scattered. Mr. Lichtner found from experience that the average employee would only make his bonus 85% of the time. This, of course, includes some performance above task, and many just below task. Using this same factor he derives what he calls "proposed wages," which he inserts in a similar formula:

$$\text{Increase in wages} = \frac{\text{Proposed wages} - \text{Present wages}}{\text{Present wages}} \times 100$$

$$\text{Saving per hour} = \text{Present cost} \times \left(1 + \frac{\text{Increased}}{\text{production}}\right) - \frac{\text{Proposed}}{\text{cost}}$$

In one application of these formulas, Lichtner found the increase in production to be 45%, the increase in wages to be 29%, and the decrease in cost per year to be $40,630.68. In another case, the author displaced old-fashioned piece rate with differential piece rate, Figure 13. A 5% step was given in piece rate at 80% efficiency and an additional 7½% step at 100% efficiency; the increase in production rate at the end of five months was 25%, while the bonuses amounted to only 2½% of the total wages. In this same case there had been a 7% increase in the average production rate between the time that job standardization was begun and the time the new bonuses were put into operation, a period of three months per department. A crude day production chart was kept for individual operators to help them visualize the "pile" of boxed product which they put out. This record of a single operator is given, one for three weeks in February (Figure 14) and one for four and one-half weeks the following June (Figure 15). The bonus was first given at the beginning of May. Note the steadying effect as well as the increase. Management literature is full of such cases, many of them showing much greater percentages of improvement.

The Aim of Incentive Designers.—Study and experience both indicate that incentives should be tailor fitted to conditions and we heartily endorse Mr. Benge when he says, "If job evaluation is used to determine the base rate, and incentive is paid above that, then I believe varying percentages for standards of varying attainment-difficulty are justifiable. To get people to step up, a stronger incentive is needed under some situations than under others."[6]

In short, no one who has had long experience in this work or who studies the original presentations of the various plans can miss seeing that designers are all groping for the incentive that will successfully hold the maximum number of employees near the maximum

[6] E. J. Benge, A. M. A. Personnel Series No. 49.

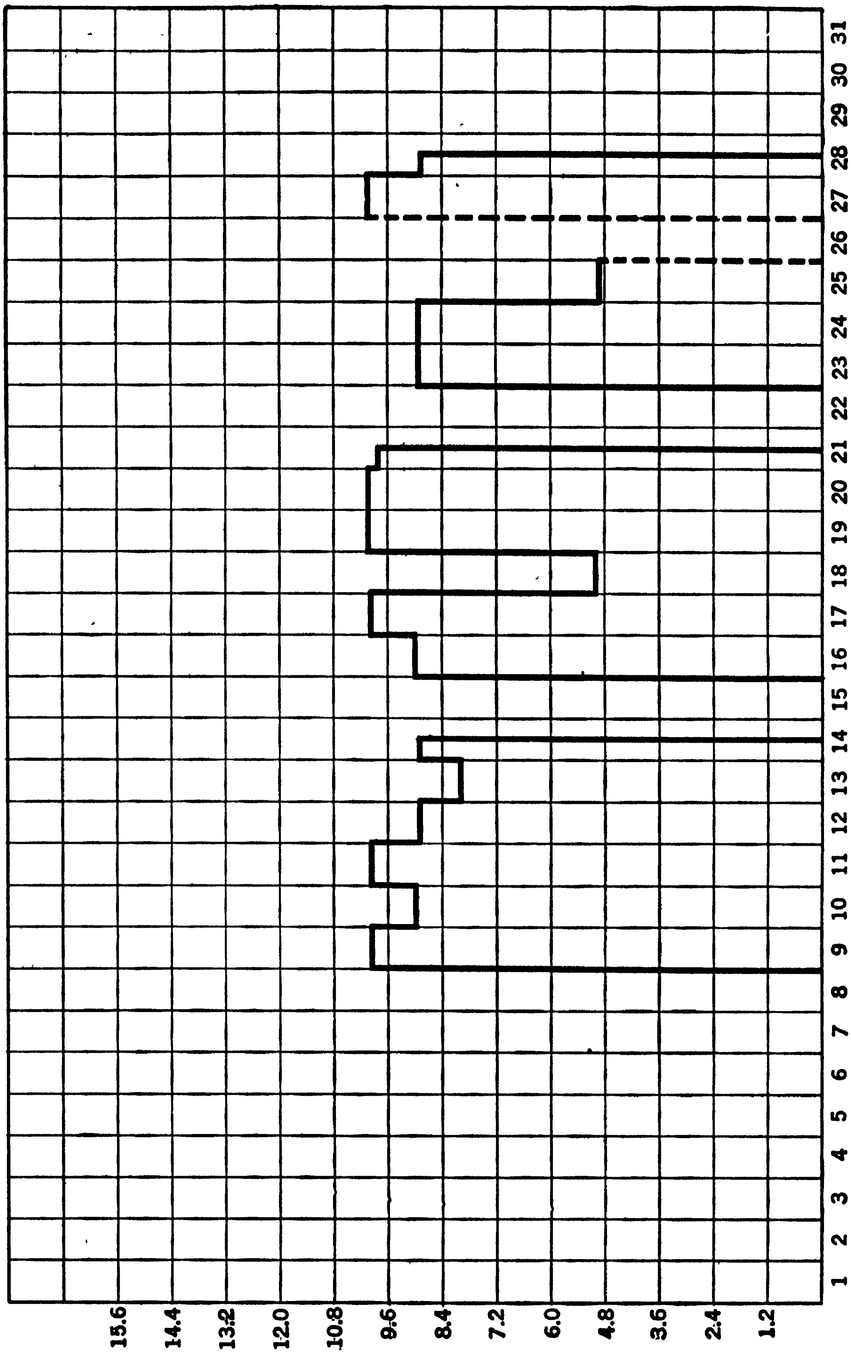


Figure 14. Individual Production Record for Month of February, 1920

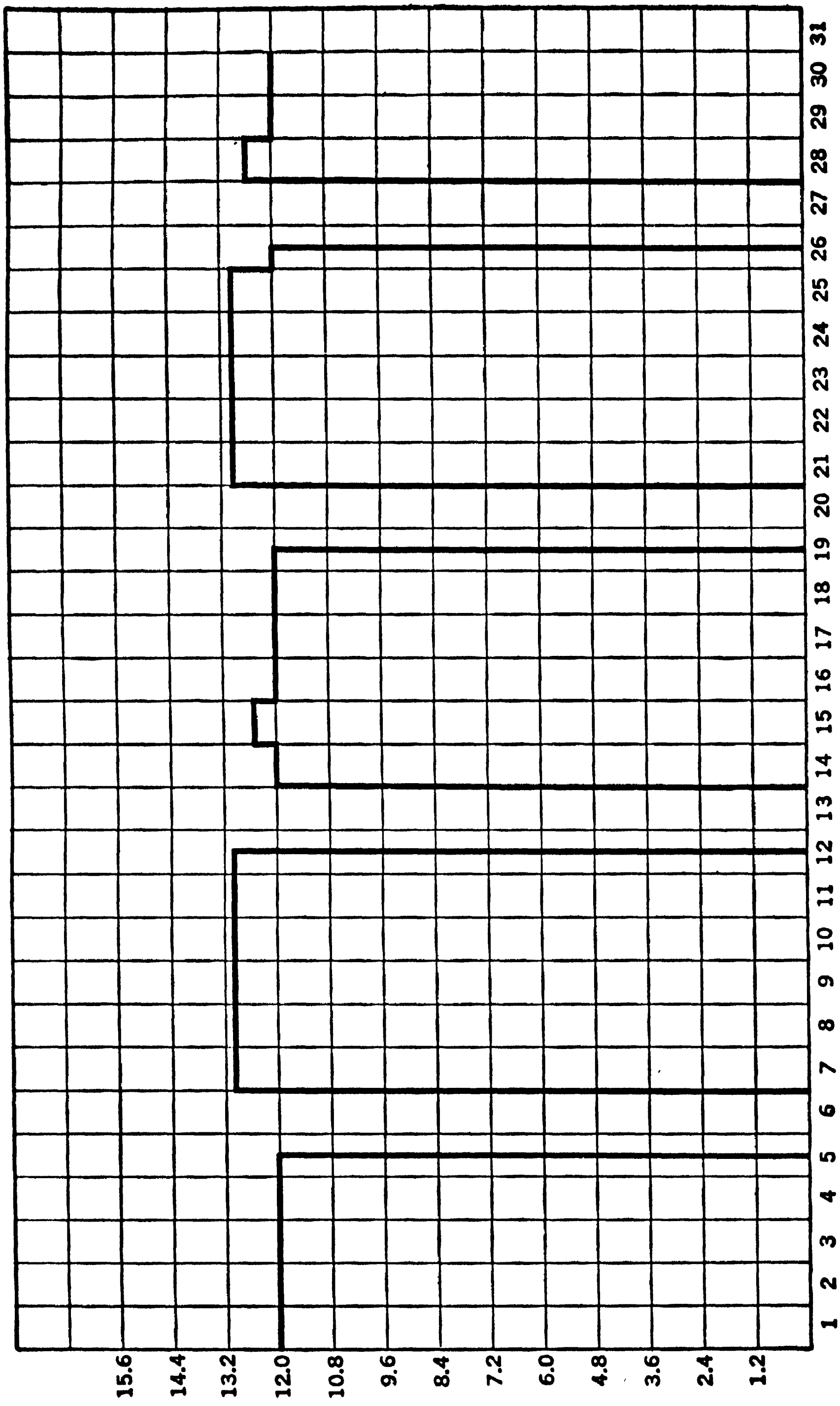


Figure 15. Individual Production Record for Month of June, 1920 (same operator)

productions of which they are capable. All factors in a department and all employees involved must be considered over a period of weeks in estimating the merit of a wage plan. This increases rather than lessens the importance of the employees as individual men and women because it is the optimum performance which must be decisive. The recognition of a point of efficiency-earning for the average of a department of employees and working backwards from that to the selection of some earning curve, the slope of which is consistent with the character of the job task involved, does not mean fixing a limit for the earning of any individual in that department. It is, in fact, the scientific way of deriving the most suitable arrangement for given conditions.

Using Profit Data as a Guide.—It is but natural for an employer to seek guidance on wages in his financial accounts. Too close-sighted attention to these has frequently led to pessimism and over caution but that need not be so. As a man about to sell property may deliberately spend money on some improvement and thereby enhance both the certainty and price of sale, so an employer knowing his profit requirements may deliberately set aside a sum for incentives which may be made to assure high production and lower total cost. A demonstration of this procedure referring to payment of salesmen but applicable in principle to any group of employees is provided by H. G. Crockett.[7]

"Table 17 shows the starting point of all the calculations. We will assume that manufacturing costs are known. If not, this procedure will not work. Costs are a necessary foundation on which to build any kind of plan. We have started in the middle column headed 100%, and we have established what we call for that particular industry a 100% task or normal quota of sales. Then we have worked out what would be 80% and 90%, and 110% and 120% of the quota. It is not essential to start with an absolutely correct quota as long as the other figures are worked out fairly and accurately to correspond to the several quotas of sales.

"We have taken 100%, Table 17, as normal production for the factory. That must be considered as a salesman is supposed to take care of the volume of production which the factory is built to turn out. It must be sold, so much per each territory.

"The manufacturing cost is 65% of the sales price. If the factory is not run at full capacity.there is an unabsorbed expense which must be covered in the selling price before there is a profit, that is, if a salesman does not sell the quota set for him, he has charged against

7 A. M. A., Marketing Ex. Series No. 40.

TABLE 17. DETERMINATION OF GROSS AMOUNTS AVAILABLE FOR SALESMEN'S PAY

Item	80%		90%		100%		110%		120%	
	Amount	Per Cent	Amount	Per Cent	Amount	Per Cent	Amount	Per Cent	Amount	Per Cent
1. Sales	$4,000[1]	100.0	$4,500	100.0	$5,000	100.0	$5,500	100.0	$6,000	100.0
2. Manufacturing Cost	2,600	65.0	2,925	65.0	3,250	65.0	3,575	65.0	3,900	65.0
	$1,400	35.0	$1,575	35.0	$1,750	35.0	$1,925	35.0	$2,100	35.0
Burden										
3. Overearned							11	.2	22	.4
4. Underearned	22	.6	11	.2						
5. Gross Profit	$1,378	34.4	$1,564	34.8	$1,750	35.0	$1,936	35.2	$2,122	35.4
6. Expenses	980	24.5	1,000	22.2	1,000	20.0	1,040	18.9	1,090	18.2
7. Net Profit	$398	9.9	$564	12.6	$750	15.0	$896	16.3	$1,032	17.2
8. Acceptable Net Profit	198	4.9	311	7.0	450	9.0	546	9.9	624	10.4
9. Per Cent of Net Profit to Investment	5.3%[2]		8.3%		12.0%		14.6%		16.6%	
10. Profit compared with 100% quota	44.0%[3]		69.1%		100.0%		121.7%		138.7%	
11. Available for Salesmen's Pay	$200	5.0	$253	5.6	$300	6.0	$350	6.4	$408	6.8
12. Effective Total Pay compared with 100% quota	65.6%[4]		84.0%		100.0%		117.3%		136.0%	

[1] Amounts represent millions —000 omitted.
[2] The example assumes an investment (total outstanding capital stock and surplus) of $3,750,000.
[3] i.e., $198,000 profit = (5.3% on $3,750,000 investment) = 44% of $450,000 profit at 100% quota.
[4] $200,000 for salesmen = 66.6% of $300,000 at 100% quota.

him a certain percentage of the unabsorbed factory capacity, which he will have to carry before there is a profit.

Budgeted Expenses.—"Then we have gross profit, line 5, below which it is just a question of cutting and trimming until an acceptable net profit for the company, the expenses for the sales organization, and what is left to pay the salesman becomes evident. These expenses as we have distributed them are the budgeted expenses for these various volumes of sales. It is evident that sales expense is not the same for 90% or 110% of the volume as it is for 100%. Some items remain the same and some do not.

"Under expenses, line 6, everything is budgeted except salesmen's salary and expenses. In this particular case the salesman was paying his expenses out of his commission rate. If the company had been paying the expenses, they would be included in item 6. Here it was left in the item available for salesmen's pay.

"Next we come to Net Profit and below that, Acceptable Net Profit. The trouble with budgets is that most people think of them only as setting a standard of expense. That is not a complete budget. Instead of saying we are going to spend so much money for this, that and the other item of expense, we ought to say that out of a certain volume of business we should have a certain percentage of net profit. Working backward from that point, that is, taking the net investment in the business and saying what is a fair net profit will give a helpful forecast of the business. We may say an acceptable net profit is 10% and conclude we cannot possibly get it at present but that is what we are attempting.

Starting Out on a Fair Basis.—"Starting this way it will soon be seen that whatever is added to one item must be taken from another. If expenses increase, acceptable net profit decreases. If the latter is to be increased, what is available for salesmen's pay will diminish in the same amount. In other words, there has been determined how much money there is to pay the salesmen and to pay the company a profit, and that is the only way to start out on a perfectly fair basis to management, stockholders and men.

"We have in line 11 percentage figures available for salesmen's pay. It ranges from 5% up. Many people have the idea that the larger the volume of sales, the lower should be the rate. It would probably vary between companies according to their policies. The principle is to begin on this basis and then determine what to give the salesmen and what to keep for management.

"We have determined that on 100% of the volume the per cent of net profit on the investment is 12, line 9. We call that 100% in line

10. Now, we find that if we increase our volume to 110%, our per cent of profit on the investment is 14.6%, which is an increase over the 100% volume of 21.7%. At 100% of volume we have $300,000 available for salesmen's pay, or 6% of total sales. At 110% we have $350,000, or 6.4% of sales, but 6.4% is only 17.3% increase over 6%. In other words, when volume is increased to 110%, the company, under these figures, takes 21.7% increase, and the salesmen only .4%. So while the salesman actually receives more for every dollar of sales, he does not receive any more than the company. This procedure is sound in its basic principles and there is no kind of business to which it cannot in some form or other be adapted. It cannot be done overnight, because there is much preliminary work. Regulating or changing salesmen's pay is a delicate matter, and must be done carefully. If no quota or budget plan has been set up, that should be done and tried out for at least a year with the salesmen to convince them that the figures are reasonable and equitable."

Recommendations.—The Coolidge era brought about two able and disinterested studies of wage plans which are still worthy of attention. The first in 1926 by the Manufacturers Research Association, reprinted by the Boston Chamber of Commerce, and the second in 1928 by the Committee on Industrial Relations, National Metal Trades Association. The report of the former entitled "Principles of Wage Payment" advocates the following principles:

I. Piece Work—used loosely to mean payment of the individual on the basis of amount of production. The plans of Cheney and Dennison are mentioned by way of illustration.

A—Standardization of shop prior to time study.

B—Production rates set only on accurate time study.

C—Establishment of definite tasks such that good average worker's attainment of them would represent 100% efficiency.

D—Guarantee of minimum day work rates in all cases where failure to perform task may be due to conditions beyond operatives' control.

E—Establishment of definite breaking-in periods.

F—Provision of exact and comprehensive instruction and rate cards.

G—Flat reward for improved operation method followed by a new rate for same.

H—Use of accurate production and scrap records and wherever possible a bonus for minimum scrap.

I—Use of a weekly analysis sheet for executive control of labor costs.

J—Control of proper ratio of indirect to direct labor.

K—If desired, the use of an indirect labor bonus based on above ratio.

II. Group Piece Work—usual group efficiency based on points with individual rate proportion of allotment.

III. Day Work with records.

A—Wherever establishment of standards cost more than expected savings from the procedure.

B—To be replaced by piece rate when that condition alters.

The report specifically condemns: rate cutting, poor standardization, sharing employee savings with management, and using plans difficult of clear understanding.

National Metal Trades Association's Report.—This report recommends eight rules which are substantially like the ones given above.

The report also says:

Your committee, therefore:

1. Urges members to use an incentive plan of wage payment whenever and wherever possible.
2. Recommends that the foregoing eight rules and principles be closely adhered to.
3. Points out the superiority of the simpler types of incentive plans, such as ordinary piece work with guaranteed day rate, over the more complex systems.
4. Emphasizes the fact that a spirit of mutual confidence and faith based on square dealing between employees and management is essential to maximum satisfaction from all standpoints.

The agreement of these reports is remarkable. The standing of their organizations and the personnel of the committees gives them great weight. We find no reason for differing from them materially. As the first report uses "piece work" to include the whole class of "production by results" plans and as both merely condemn the more complex plans, any objection would seem to be a plea of guilty to complexity. Analysis of the numerous plans here described constantly raises the question: Are all these plans needed somewhere? The answer is obviously, No! What, then, is needed?

Plans Which Are Justified, for What, Why, and How.—

1. Day Rate Plan with production records and promotion.

For unstandardized work, permanent, or temporary.

It is simple and about all that can be used.

Management should eliminate unsupported time payment wherever and whenever possible.

2. Differential Time Plan with high bonus steps.

   For upgrading employees formerly on day rates, also for group applications.

   It is strong at task point and simple at all points.

   It must be more carefully managed than a more elaborate plan.

3. High Piece Rate Plan—with or without a minimum guarantee and with the time basis of computation.

   For repetition work, not involving expensive machine rates.

   It is the simplest and the most sound of all the plans.

   Equalization requires care as task per unit of time may not be evident.

4. Merrick Differential Piece Rate Plan.

   For upgrading inefficient employees formerly on low price rate.

   It is flexible, strong, and relatively simple for what it can do.

   Tables must be used for explanation and computation.

5. Gantt Task and Bonus Plan (a combination of #1 and #3 with step between).

   For machine jobs liable to delay and where machine rates are high.

   It provides security with strength.

   The day guarantee may need watching.

6. Halsey (50-50) Constant Sharing Plan with Time Guarantee.

   For guessed-at-standards, no big machine rates.

   It gives a high wage through intermediate production efficiencies.

   Task or rate inaccuracy is less serious.

7. Halsey (40-60) Constant Sharing without Time Guarantee—up to 70 or 75% of high task.

   For beginners, skilled work.

   It compromises for low efficiencies.

   It is simple to understand.

   This plan is not recommended above task.

8. Bedaux Point Plan.

   For strongly centralized management and for widely diversified operations.

   It gets results through its production control rather than through improved operations and high rates.

   It involves a lot of figuring.

9. Barth Variable Sharing Plan—up to day wages only.

   For beginners, unskilled work.

   It gives a high wage for low production efficiencies without any guarantee.

   Tables must be used, the new employee may not have a slide rule.

   This plan is not recommended above task.

10. Emerson Empiric Scale Plan—between 70% and 100% task only.
    - For gradual transition from day work plan to high piece rate plan.
    - It avoids the abrupt step and may be justified in some cases.
    - The empiric principle should be used only within the above limits, outside of these, other plans are preferable.

11. Accelerating Premium (Parabolic) Plans—most generous of all earning curves above high task.
    - Complies with Fair Labor Standards Act without guaranteeing full time rate.
    - Rises gradually through high average-response point (100, 120).
    - Pays better than high piece rate for highest efficiencies.
    - Makes a one curve plan for all points, can use a family of curves.
    - Not complex after data are tabulated.
    - This plan is recommended where machine rates are not high but where high tempo work is wanted. Also for supervisors.

As to the other plans, subsequently presented in detail, none of them have inherent merit not to be found in the above, except perhaps the fifteen class gradation of Parkhurst. If the scale of Efficiency-Bonus seems important, that may be made up for any of the above plans. Job standardization, production control, inspection, and non-financial incentives must precede and accompany any plan to get anything worth while out of it. Similarly, any one plan may be applied to a group or put on a man-minute basis. We may be wrong, but with malice toward none, we sincerely believe that these eleven plans provide us with every kind of incentive which we need today and which we are likely to need for a long time to come. Various combinations of these plans are desirable, but they should not be given new names other than perhaps plant names indicating where used.

Suitability.—Referring to the foregoing eleven plans: Numbers 1, 7, 9, and 11 are most suitable below and up to task, high or low.

Numbers 2, 3, 4, 6, 10, and 11 are most suitable for the intermediate range, as between low and high task.

Numbers 2, 3, 4, 5, 8, and 11 are most suitable above high task.

Various combinations from these plans may be utilized to meet almost any conceivable set of conditions. By way of example see the Barth-Gantt Combination Plan, Chapter 17.

Deciding on the Earning Curve.—When conditions and methods have been improved, as far as may be expedient, specific jobs standardized and evaluated, policy and desired emphasis determined, then management is ready to adopt, modify, or design the most

suitable earning curve for each particular set of jobs. Usually a plan in use for like conditions elsewhere is adopted because it is thought that copying will avoid all experimentation. Actually there is bound to be some experimentation even in exact copying because some minor conditions, if only the personal factors, can never be found identical in any foregoing case. The history of each situation is also virtually unique and that alone has an important bearing on what earning curve will be most suitable. Hence it is not necessarily more experimental to modify a plan or to combine portions of different standard earning curves provided this is done in conformity to correct principles. An entirely new design should be safe in competent hands but there would still be some experimental risk even if kept within correct principles. Whichever of these means is followed the same steps are involved, viz.:

1. Ascertaining the kind of task, high, intermediate, or low.
2. Setting the necessary earning to get task efficiency.
3. Estimating the desired average response in terms of efficiency and earning.
4. Knowing the degree of machine charge or burden involved.
5. Bearing in mind the history of the case, union attitude etc.

From steps 1 and 2 one point on the standard chart will be determined and can be checked on its relation to the basic point (100, 100). From step 3 a higher point will be determined. This point is the most difficult since it can only be judged from experience with similar conditions some of which may be illusive. Consequently this point should be assumed conservatively and tentatively. From step 4 it will be evident whether or not a step bonus should be inserted. If a single step is desirable, the amount of it is determined by the vertical distance from base time wages to the necessary earning at task, step 2.

Various earning lines may now be drawn to conform to the above determinations, compromises made if necessary and all checked against step 5. No one should attempt the design of an earning curve who has not had considerable experience with the kind of jobs involved, the particular human factors and, last but not least, with the principles treated at length throughout this text. At this stage the cost curves should be worked out so that a full realization may be had of what is involved for the likely range of efficiency, particularly for the estimated point of average response.

For an example of selecting incentive plans for indirect production work see Production Handbook, 1944, section on Wage Plans.

CHAPTER 4

METHODS OF STUDYING INCENTIVE PLANS

"Wage incentives, together with the tools of measurement, analysis and appraisal, have taken an important place in the industrial world."—E. S. HORNING, N. I. C. B. Studies in Personnel Policy, No. 19.

Analysis Obviates Trial.—Doubtless the wide variation or divergence which first characterized the incentive movement was a natural phase of evolution. But the process of elimination always follows that of divergence. Elimination may come from practical "trial and error" or it may come from analysis and avoidance. This latter procedure has not been brought to bear on all incentive plans until recently. In our approach to this analysis, it was found that the early writers on the subject scarcely spoke the same language and rarely presented plans in comparable examples. Charts did not lack definiteness but did lack consistency throughout the field. A consultant would chart his plan in the most favored position, and the prospective client would be unable to find similar presentations of other plans. Defined standards and formulas which could be used as checks regardless of the plan had not been developed.[1] It is the purpose of this chapter to explain all the necessary steps of incentive analysis so that the reader may check the procedure throughout the book, and so that he may undertake similar analyses without the arduous work of establishing procedure.

Preliminaries of Analysis.—The first step is to set up a definite terminology and a uniform treatment. For the sake of comparing like quantities in several distinct combinations, it is necessary to assume that certain other variables are constant. This is done in regard to the quality and material economy factors. For instance, it is not ignoring these factors to suppose that an inspection department is able to control them both to normal variation. In fact, the requirements in regard to these two phases may often be so rigid that the work will not be accepted if it falls outside the most narrow

[1] This development was begun by us in *Management Engineering*, May, 1922, was carried further in *Management's Handbook*, 1924, and is now described here in detail for the first time. (First Edition of this book, 1929.)

limits. It is futile never to compare quantities of production and wages merely because there are other accompanying variables. If this course were denied us, we should never compare any quantities involving human labor, since no two men are exactly alike.

The Earning Curve.—The primary consideration of an incentive is the earning curve. As this is a definite locus between the amount of production and the amount of wages paid as earning, and as production is the independent variable, the abscissas or horizontal axis is taken as production and the ordinate or vertical axis as the wages earned. These are scaled in percentage in order to allow easy application to any specific case. From these scales the point (100, 100) becomes the most important point for the comparison of all curves and is called the "high-task, base-wage" point. The point (62½, 100) is called the "low-task, base-wage" point. By 100% base wage, we mean the competitive time rate for a given job or class of work in the locality. This is discussed in Chapter 1. Formulation from prose description is demonstrated under headings, "Formulas for Earning."

Variation of Tasks.—A novel concept of the task is found in the case of a large eastern chemical company.

1. The ideal standard is set so high that it is impossible of attainment.
2. Every employee is given an hourly rate which is carefully derived.
3. The daily production of each employee is measured against the standard, charted, and watched by both employers and employees.

It is claimed that this plan works well and that superworker is just as proud of 95% efficiency as of 145% relative to the more usual task location. In reality the only difference between such a standard and one with allowances on absolute minima is a matter of scales. The use of allowances is the more common practice, so that it is awkward for new employees from other shops to adapt themselves to the ideal task conception.

According to Lichtner,[2] the task used by Barth, Baum, Halsey, and Rowan would allow performances of around 200%. "Under the Emerson plan a large number of employees will produce from 125 to 150% of standard. Under the Taylor and Gantt plans production of more than 110% will be very rare." In this treatment

[2] *Management Engineering*, July, 1922.

of task we are merely concerned with production quantities, not with employee difficulties.

Tasks in General Fall Into Two Classes.—While the task standard varies among different companies, from perfection down, it is sufficient to use only two task standards, one called high and one called low, because all plans have been devised for either a standardized plant or an unstandardized plant. Tasks for the former are called high and are assigned the 100% location on the production scale. Tasks for unstandardized plants are called low, and as they are commonly from 60% to 65% of the high task, they are assigned the 62½% location on the production scale. High task does not mean maximum capacity or perfection. Actually, it varies with policy and the pains taken in determining it.

A large machine tool company recently tried the experiment of having several time study men separately analyze identical operations. The tasks determined by them varied less than 10%. This high task should be set so that most competent employees can make it day in and day out without extreme effort. Some of the more energetic employees will range around 125% of it frequently; and the rare, but well-known superworker will be able to make up to 145% of it. About 150% production is, therefore, the perfection location or full mechanical capacity and earnings beyond are con-

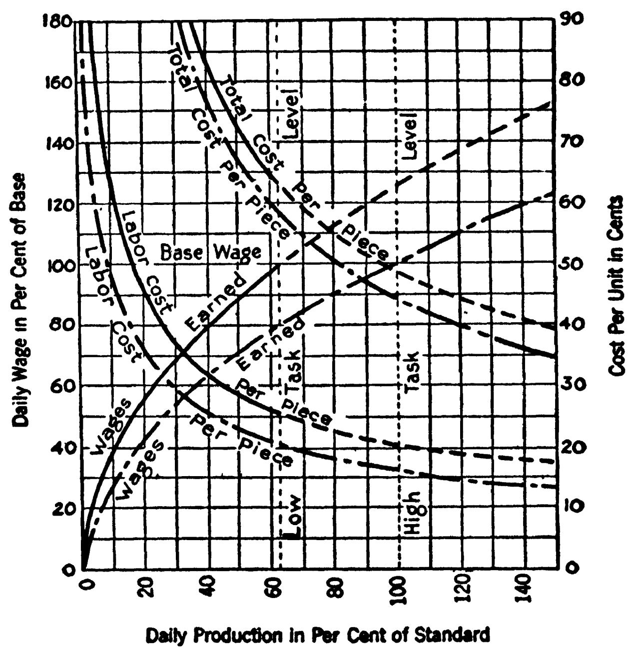


Figure 16. The Barth Variable Sharing Plan—shown for two task levels. The lower level is the one for which the curve is designed.

sidered as merely theoretical. As a matter of fact, any one employer would have his own method of determining this task so that any plan he might choose to adopt would go in on that single task. The employer needs to know how the various plans differ relative to each other for a single low or high task.

Of course, plans designed for one of these two tasks may be grotesque if applied to the other. The least affected by task change would be the plan having the least slope through high production points, where the greatest divergence must occur. The Barth plan meets this condition and is shown in Figure 16, through low task level as designed, and through high task level as misapplied. In the latter position, it provides so meager a premium above task that it would be useless as an incentive. A steep slope plan, on the other hand, can give an impossibly high wage when misapplied through a low task. This is what happened so often with pre-time-study piece rates.

Use of a Low Time Rate.—The 100% base wage is not always used for day guarantee. It is fairly common practice to use a minimum or low time rate as a guarantee in connection with a strong incentive. In the clothing industry 65% of average hourly piece rate earning has been used. The practice makes some confusion in terms such as base rate, day rate, guaranteed rate, etc., but it may be considered necessary to avoid making the guarantee too attractive. Since many companies prefer to hire all employees at a rate about 80% of what can be given later, the practice does not necessarily mean a set-back in the time rate. The lower time rate certainly removes the main objections to guarantees in connection with extra-financial incentives, but it must be handled cautiously where the hiring rate is the full competitive day earning. As you can elevate an object by using either a jack or a lever, so you can raise an earning locus either by inserting an additional percentage of base time rate or by increasing the slope of the incentive rate. The locus can similarly be lowered by either.

Low Guarantee with High Base.—As an example of the low guarantee rate, we chart the plan of a mid-west company making plows. An 80% time wage is used with a high piece rate which passes through the point (82, 100). This is practically the rate used by Gantt and Merrick above 100% task (Figure 17).

"In general, we figure that the base rate, which is to say the rate we expect an average man to earn working piece work, is about 20% above the standard day rate. A man will run 10% to 15% above his base rate.

"This company may be exceptional in its practice of dealing with men individually. We are very careful in all our rate-setting and handling of jobs and men that natural speed and superiority are not handicapped. In almost every department you will find exceptional men earning way above normal, but we are glad to have this so and we go to considerable length to see that rates for this work do not suffer because of this superiority. Piece rates do vary, and the men who are working under them vary on exactly the same class of work. This to some extent is due to experience but to a greater extent to individual variation in men."

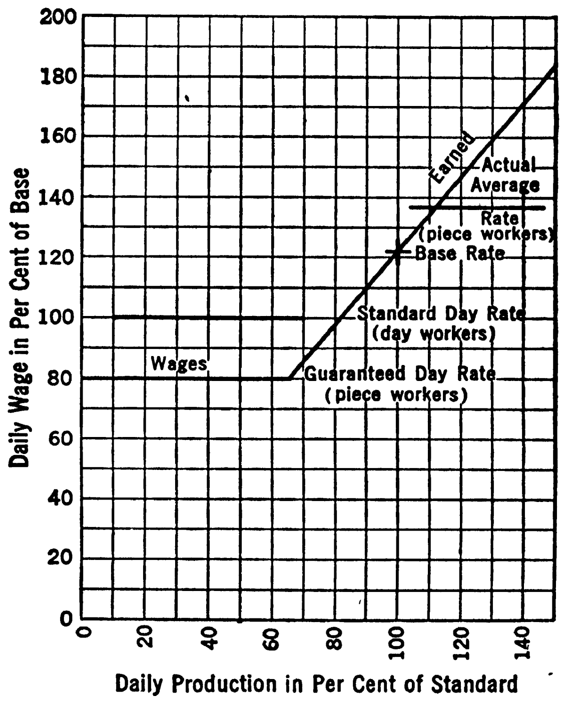


Figure 17. High Piece Rate with Day Guarantee Plan

Probable Efficiency Earning Points of Most Significance.—Referring to Figure 18, we see that the two most definite limits for all wage charts are "perfection" (150, 200) and "near discharge" (60, 100). The "superworker" is also fairly definite. The other point locations are a matter of experience and would vary a little under different circumstances. The "low task" point is located by the record of many day workers. The "high task" point is the task as set by Taylor, Gantt, and other thorough motion-time-study engineers. Most variable of all are the "low task average" and "high task average." This is because they depend on the net effect of the incentives, or on the average response of whole departments. As the

incentives range all the way from very weak (a) to very strong (A), this point for any particular incentive may be anywhere between the two shown or slightly outside. These points will clarify terms used in the book and will be of interest in connection with the chapter on Selection. These average response points are the only true bases for comparison of plans, because they determine the amount of production over which the overhead is distributed in deriving the total cost per unit.

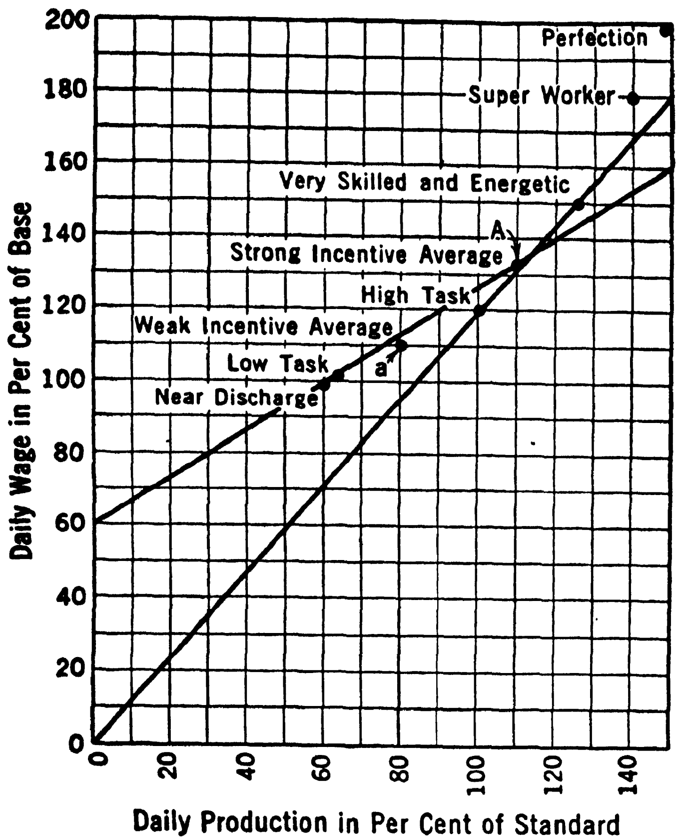


Figure 18. Probable Efficiency—Earning Points of Most Significance

Any incentive located along the lowest three points is a weak one, and any located along the remaining points is a strong one, if it is properly managed. The ideal incentive is indicated by these points and is an increasing slope, that is, with the concave side uppermost. The older emphasis of labor cost rather than the new emphasis of total cost led to the popular conception that an incentive should increase less rapidly than production. The correct postulate is that an incentive should increase as rapidly and, when possible, more rapidly than production. The adoption of high or low task is deter-

mined by the degree of standardization, so that the choice of a desired average efficiency-earning point, *a* or *A*, will determine the slope of any straight earning curve.[8]

Production Assumptions.—The lower limit of probable production is determined by the discharge policy of the company. We have taken 60% as a reasonable termination. Between this 60% production and the 145% production, we have chosen seven points, making nine altogether, and worked out the earning for over two dozen plans on these same nine points. The selection of these points was made by taking even hours gained or lost by an employee as compared with task production. This is arbitrary and merely tends to emphasize in the tables the value of such time gains or losses. Taking the time in round numbers makes the production percentages uneven, but the points are here given so that any one may check the tables.

Cost Assumptions.—The costs are assumed in dollars, not in percentages, because it seems unthinkable to use any figures that may be construed as setting up some law for the proportion of overhead, material, and labor. In other words, the cost figures are only for a single assumed case and would be different in all respects for any other case. By using one set of assumptions, however, we may see how the various earning curves affect costs relatively.

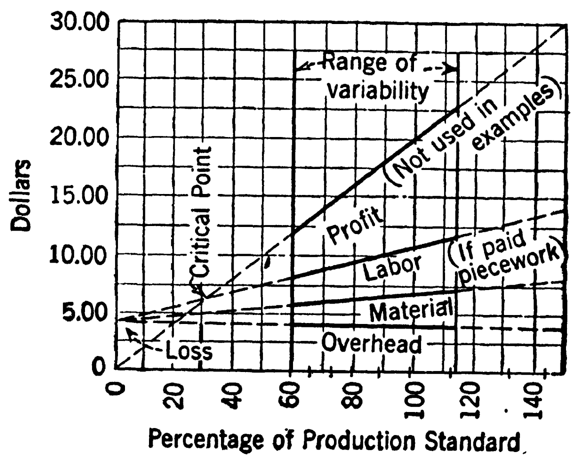


Figure 19. Assumed Financial Distribution on a Man-Day Basis

(For example of more extended use of this chart, see *The Successful Control of Profits*, by Walter Rautenstrauch; also *Factory*, April and July, 1930.)

Explanation of Chart.—Figure 19 is the familiar break-even chart used to illustrate the fact that there is no profit below some point of production. Overhead is drawn horizontally, which is

[8] It may be desired to connect the two points as in Figure 51.

approximately true, and the other two cost elements, material and labor, are added in progression. Of course, the curve showing income from sales must start from the origin, so that the triangular area at the left of the intersection represents loss, and the complementary area represents profit. The profit and loss quantities are not used in the examples; they are merely assumed so that the chart may be recognizable. At 100% task:

Time wages are fixed at	\$ 3.84	(basic piece work also)
Material cost is fixed at	2.88	(24 pieces at \$.12 each)
Overhead cost is fixed at	3.84	(Arbitrarily taken at 100% of time wages.)
Total cost	\$10.56	per man-day

Note that *other proportions will materially alter the total cost curves.* For instance, if the proportion of burden to wages is higher, then the total cost per unit will be higher and flatter, particularly *flatter through the hightest efficiences.*

Because the wages are different for the different plans, we are only concerned here with two elements. The values in Table 18, lower row, are derived for each point as follows:

Overhead + Material	$= O + M$
\$3.84 + \$2.88	= \$6.72
$O + M \div$ No. of Pieces at task point. Alter for each point.	= Extra Cost per unit of production, besides labor.
\$6.72 ÷ 24	= \$.28

TABLE 18. PRODUCTION POINTS AND COSTS USED IN TABLES AND CURVES

Production in percentages.	0	10	20	30	40	50	60	66	73	80	89	100	114	133	145
Corresponding cost per unit of overhead plus material in dollars*	3.84	1.72	.92	.65	.52	.44	.39	.36	.34	.32	.30	.28	.26	.24	.23

* These figures plus direct labor costs equal total costs.

Symbols for Formulas.—Before curves can be plotted there must be statistics covering the chosen points, and before these statistics can be obtained there must be a formula for the earning under each plan. Such formulas are easily written from plan descriptions, provided a workable set of symbols is established. The following symbols are mnemonic and have been in general use since their publication:[4]

[4] *Management Engineering*, May, 1922.

*General Key to Symbols**

E = EARNINGS IN DOLLARS (A VARIABLE)
R_h = RATE PER HOUR IN DOLLARS ($.48 in specific cases)
R_p = Rate per piece in dollars ($.16 in specific cases)
R_t = Rate per time unit longer than an hour, also
Sub. d = per day
Sub. w = per week
Sub. m = per month
Sub. y = per year
H_a = HOURS ACTUAL (made CONSTANT for a day of 8 hours)
H_s = HOURS STANDARD (made VARIABLE, inverse to efficiency)
H_{sl} = Same as above for low task on standard abscissas
H_{sp} = Hours standard per piece
L_s = Standard lapse or idle time divided by standard time
L_a = Actual lapse or idle time divided by standard time
N_p = Number of pieces produced, $N_{pd} = N_p$ per day
B = Guarantee rate in per cent of standard or going rate R_h, may be unity
B_o = Bonus in per cent of $B\ H_a\ R_h$, a constant, $B_{od} = B_o$ per day
P_r = Premium in per cent of $(H_s - H_a)\ R_h$, a variable, $P_{rd} = P_r$ per day
I = Incentive portion of E, viz.: $(B_o + P_r)$
F = Factor of labor's share in per cent of time saved
F_d = Factor of deduction in per cent of time saved
M_a = Minutes actual
M_s = Minutes standard
m = Slope of earning curves or their tangents at specified points
W = Wages in per cent of standard at task efficiency
C_s = Cost per unit at standard
C_a = Cost per unit actual
K = Special constants

Elements Underlying All Financial Incentives.—Only a few of these symbols are necessary for most of the formulas and they may be learned by use in a few seconds. For instance, by definition:

(1) Piece Rate Earning = No. of Pieces × Rate per Piece
$$E = N_p \quad R_p$$
(2) Time Rate Earning = Hours Actual × Rate per Hour
$$E = H_a \quad R_h$$
(3) Time Saved = Hours Standard − Hours Actual
(no symbol) $= H_s - H_a$
(4) Wages Saved = Time Saved × Rate per Hour
(no symbol) $= (H_s - H_a) \quad R_h$

* The four symbols with definitions in CAPITALS are the most important, in fact, are the only ones essential to most of the discussions.

As all plans, excepting those of Barth and Accelerating Premium, are made up entirely of quantities (2) and (4) or some combination of them, it is not hard to derive any earning formula. This was done and then the specific points were inserted, that is, nine examples were worked out for each plan and the earnings, costs, etc., put into table form.

Working Out Statistics.—The following will illustrate the procedure for statistics:

#1	#2	#3	#4	#5	#6	#7
Per Cent of Production	Per Cent of Total to Base Wage for Full Day	Total Daily Wage in Dollars	Number Pieces per Day	Time Saved per 8-Hr. Task in Hours	Labor Cost per Piece in Dollars	Total Cost per Piece in Dollars
H_s/H_a	$E/H_a R_h$	E	N_{pd}	$H_s - H_a$		C_a

Referring to the columns by numbers as above,—

#1 lists the chosen production points, which are used for the horizontal scale.

#5 is the controlling one and is assumed as already described.

#4 is worked as follows:

#1 Per Cent of Production	Task		Hours Standard / Hours Actual		#4 No. Pieces per Day
89	24	×	8/9	=	21.4
114	24	×	8/7	=	27.4

Note that data are figured for an 8-hour task, rather than for 8 hours of actual work. Despite this, time wages $H_a R_h$ is the constant for a day and per cent efficiency H_s/H_a, is the horizontal variable. Per cent of earning $E/H_a R_h$ is the vertical variable. Referring to any point on the wage charts shown in this book, we give the horizontal value first and the vertical value second as point $(H_s/H_a, E/H_a R_h)$ or low task point (62½, 100).

#6 is worked as follows:

#3 Total Daily Wage in Dollars		#4 Number Pieces per Day		#6 Labor Cost per Piece in Dollars
3.84	÷	21.4	=	.18
3.84	÷	27.4	=	.14

#7 is worked as follows:

#6 Labor Cost per Piece in Dollars	+	Overhead and Material Cost*	=	#7 Total Cost per Piece in Dollars
.18	+	.30	=	.48
.14	+	.26	=	.40

* Values taken from Table 18.

Correction for Full Day.—Where the wage is other than for straight time, the amount figured by formula for any efficiency must be prorated through the whole 8-hour day. For instance, suppose we are figuring the earning under the Emerson efficiency bonus plan. At 145% production there are 2.5 hours time saved, so that the formula gives the earning for only (8 — 2.5) or 5.5 hours' work. The employee does not usually go home for this remaining 2½ hours but continues to work at the same efficiency rate. If we are interested in the earning at that efficiency for an 8-hour day, we must multiply the formula result by 145%. Otherwise the earning shows less and less as the efficiency increases! In formulas which include the expression $H_a R_h$ the H_a must not be treated as the full time per day, except at 100% task, or this correction will be wrong.

From Table 46, the formula gives us the following at 145% efficiency:

$$\begin{array}{rll}
\text{Earning} & = \text{Time Wages} + \text{Wages Saved} & + .20 \text{ Time Wages} \\
E & = H_a R_h + (H_s - H_a) R_h & + .20\, H_a R_h \\
E & = 5.5 \times \$.48 + (8 - 5.5)\,\$.48 & + .20 \times 5.5 \times \$.48 \\
\$4.37 & = 2.64 + 1.20 & + .53
\end{array}$$

$$\begin{array}{lcccc}
5.5 \text{ hr. Earning} & \times & \text{Efficiency} & = & \text{Day Earning} \\
\$4.37 & \times & 1.45 & = & \$6.34
\end{array}$$

Where there is neither an empiric bonus nor a guarantee of time wages, time lost, or the negative, values in column #5 are used the same way and prorated backward by the efficiency less than unity.

Simple Analytic Geometry Helpful.—Those familiar with analytic geometry will remember that in x, y coordinates the formula for slope is $m = \dfrac{y_2 - y_1}{x_2 - x_1}$ which means for any two points on the curve (x_1, y_1), (x_2, y_2) the slope of the curve is the y or vertical leg divided by the x or horizontal leg of the coordinate triangle, that is, the curve is the hypotenuse. The equation for any straight line is $y = mx + b$. For a horizontal line the x element disappears and

such a straight line is expressed by $y = b$, Figure 20. The slope relative to x is zero.

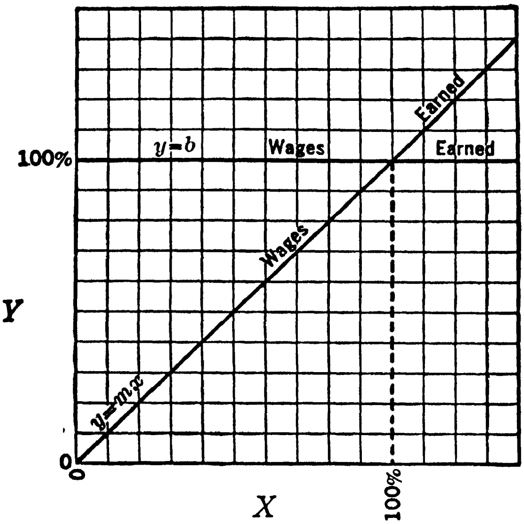


Figure 20. Basic Straight Line Wage Formulas (X, Y Coordinates)

For a straight line passing through the origin the y intercept, element b, disappears and such a straight line is expressed by $y = mx$ (m = slope). Now if we replace y by the ratio of earning to 100% base wages, viz., $E/H_a R_h$ (Figure 21) and x by the symbol for production H_s/H_a, we have for the horizontal straight line

$$y = b$$

$$\frac{E}{H_a R_h} = 100\% \text{ or } E = H_a R_h \text{ (base time wages)}$$

Similarly, we have for 45° line,

$$y = mx \text{ (no intercept)}$$

$$\frac{E}{H_a R_h} = 100\% \frac{H_s}{H_a} \text{ or } E = H_s R_h \text{ (basic piece rate)}$$

As proved in Chapter 7, this is straight basic piece rate, that is, basic when it passes through the (100, 100) point. In our earlier writings we called this "normal" piece rate. Some readers inferred that we meant the piece rate normally in use. It is difficult to ascertain what rate is the one normally in use, so that the word is now avoided. All we originally meant, and what we mean now, is that

this rate is a basic criterion, since it is fixed by base earning and high task.

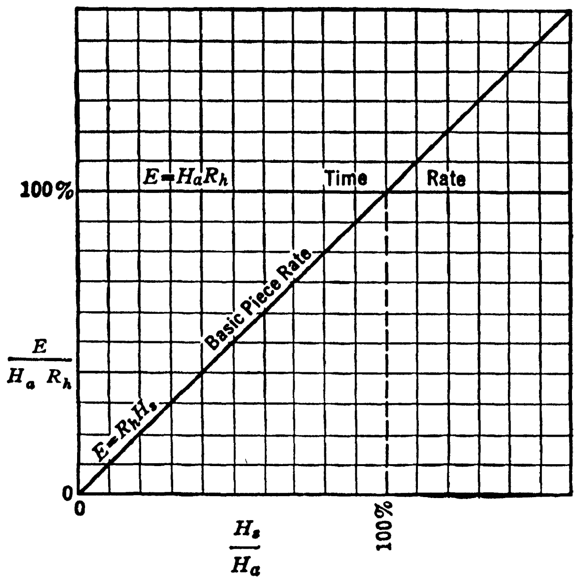


Figure 21. Basic Straight Line Wage Formulas on Standard Coordinates

Since both the 100% wage line, $E = 1.00\, H_a\, R_h$ (horizontal) and the 100% efficiency line (vertical) are basic in nature they are much used as reference lines. Their intersection point (100, 100), where time wages, efficiency, and piece rate slope are all unity, is the natural locus from which all charting should start. Since slope is the quotient of altitude divided by base and since the base at 100% efficiency is unity, the altitudes along the 100% efficiency line will give the slope direct of any earning line which forms the hypotenuse. Of course if these lines intercept the vertical ordinate at any other point than the origin, the amount or height of intercept must be subtracted to get the true altitude or slope. If the value of this altitude is unknown, then the slope must be derived from the two point formula already given. If the earning line is other than a straight line it will have a different slope at each point. In that case the equation must be expressed and differentiated. That gives the expressions for tangents from which the slopes and intercepts can be recognized for each point of interest. See equations (12) to (27), Appendix B.

Two Arrangements of Formulas Helpful.—What we will call the Type A formula is made up of the "parent" quantities $H_a\, R_h$ and $(H_s - H_a)\, R_h$. This type allows comparisons as to the amounts of bonus and premium. The Type B formula is shaped to bring out

the intercept, or coefficient of $H_a R_h$, and the slope, or coefficient of $H_s R_h$. Most of the plans can be easily expressed in both ways and one is usually about as simple as the other. There are, however, a few plans which do not easily take both forms and may become hopelessly complex in the process. Such is the case for the Variable Sharing plans and the Accelerating Premium plans. Four radically different plans may now be formulated both ways for illustration.

Type A *Type B*

1. Ordinary time wages (zero terms inserted for comparison)

$$E = H_a R_h + .00\,(H_s - H_a)\,R_h \qquad \frac{E}{H_a R_h} = .00\,\frac{H_s}{H_a} + 1.00$$

2. (50–50) Constant sharing wages

$$E = H_a R_h + .50\,(H_s - H_a)\,R_h \qquad \frac{E}{H_a R_h} = .50\,\frac{H_s}{H_a} + \ .50$$

3. Rowan variable sharing wages

$$E = H_a R_h + \frac{H_a}{H_s}\,(H_s - H_a)\,R_h \qquad \frac{E}{H_a R_h} = \left(\frac{2\,H_a H_s - H_a^2}{H_s^2}\right)\frac{H_s}{H_a} + \ .00$$

4. Basic piece wages

$$E = H_a R_h + 1.00\,(H_s - H_a)\,R_h \qquad \frac{E}{H_a R_h} = 1.00\,\frac{H_s}{H_a} + \ .00$$

In clearing for E in Type B the H_a denominators cancel leaving an $H_s R_h$ for the slope quantity and an $H_a R_h$ for the intercept quantity. It is therefore permissible to start with E alone and continue with those two quantities. From the Type A formulas it is obvious that ordinary time wages (1) with a zero share of wages-saved lies at one extreme and basic piece wages (4) with 100% or the whole of wages-saved, to employees, lies at the other extreme. This provides a natural basis of classification. (See Chapter 5.)

Intercepts.—The vertical distance between the 100% standard wage line and an intercept point measures the employee's share of saving relative to task performance, and the remaining distance to the origin measures the employer's share. The latter is "the intercept" as b in the straight line formula, $y = mx + b$. Above task a similar complementary triangle may be formed where the measures are reversed.

In such a formula as that of the (50-50) constant sharing plan, where

$$E = (H_s + H_a)\,\frac{R_h}{2} = \frac{H_s R_h}{2} + \frac{H_a R_h}{2} \quad ,$$

the term $H_a\ R_h/2$ is the intercept of 50% day wages and ½ is the slope, that is, for its task point 62½, 100).

In the (33⅓-66⅔) constant sharing plan with low task abscissas,

$$E = \frac{(2\ H_a + H_s)}{3}\ R_h = \frac{1}{3}\ H_s\ R_h + \frac{2}{3}\ H_a\ R_h$$

that is, ⅔ is the intercept and ⅓ the slope.

Relative to high task standard abscissas scale,

$$E = \left(.53\frac{1}{3}\ H_s + .66\frac{2}{3}\ H_a\right) R_h$$

In the Diemer plan where

$$E = (5\ H_s + 7\ H_a)\ \frac{R_h}{10} = \frac{1}{2}\ H_s\ R_h + \frac{7}{10}\ H_a\ R_h$$

the term $\frac{7}{10} H_a\ R_h$ shows the intercept, made up of $\begin{cases} \frac{5}{10} & \text{premium} \\ \frac{2}{10} & \text{bonus} \end{cases}$

$\frac{1}{2}$ is the slope, relative to the standard abscissas.

This test of the intercept is most helpful in understanding all straight line plans. The principles to bear in mind are as follows:

1. When the (E) intercept is positive, but less than unity, the earning can be fairly high through low production, even if the slope is slight.
2. When the (E) intercept is zero, it is piece rate regardless of slope.
3. When the (E) intercept is negative, the earning cannot be even reasonably high through low productions.

The first of these is the basic principle of constant sharing plans and explains why they are suited to low tasks. The second of these is the basic idea of all piece rates. The third of these is the reason why steep slopes are never suited to low tasks. There may be any number of different slopes for each starting point, piece rates diverging from the origin and sharing rates diverging from the (E) intercept point.

Slopes of Piece Rate Plans.—If the slope should have a coefficient greater than unity, such as 1.20, the rate would be more steep and the task lower; if it should be .75 the piece rate would be less,

etc. **This is what** we actually have in the Taylor differential piece rate plan. The rate less than unity prevails for production below task and the one greater than unity prevails above task. The short horizontal line through 133% standard earnings on Figure 22 is inserted to show that if a piece rate earner is to earn a third more than a day rate earner, he must do 132% of task if the rate is "basic" or only 110% of task if the rate is Gantt's 1.20 R_h, or just task if the rate is 133%, "high" piece rate. The trade unions of England stipulate that "a workman of average ability shall be able to earn 33⅓% above the time rate of his grade."

Thus numerous piece rates can diverge from the origin, all the way from the pre-time-study piece rate applied to the average per-

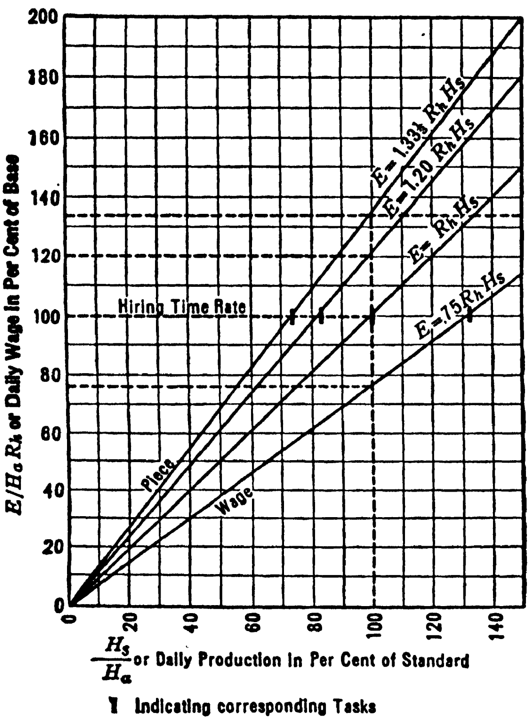


Figure 22. Slopes of Four Piece Rate Plans

formances of day workers who were 50% to 60% efficient, to the punitive piece rate of Taylor which, if extended, would have cut the day wage line at 120% of high task. The first was too good to be true in generous wages and was fated for soldiering or cutting. It often met both. D. S. Kimball[5] charts such a piece rate passing through the point (50, 100). Piece rates of this sort were mere starting rates; they did not last. The ultimate rate was at the other extreme. The punitive rate of Taylor was to "freeze out", the less

[5] *Principles of Industrial Organization.*

energetic and in doing so raised bitterness against its designer. Of course, the correct piece rate based on careful job standardization strikes between these extremes, as shown by the angle between "basic" piece rate and "high" piece rate. This illustration also demonstrates that the rate varies inversely with the task level.

Slopes of the Empiric Plans.—The Wennerlund plan uses the piece rate passing its starting point (100, 120), (Figure 23) and

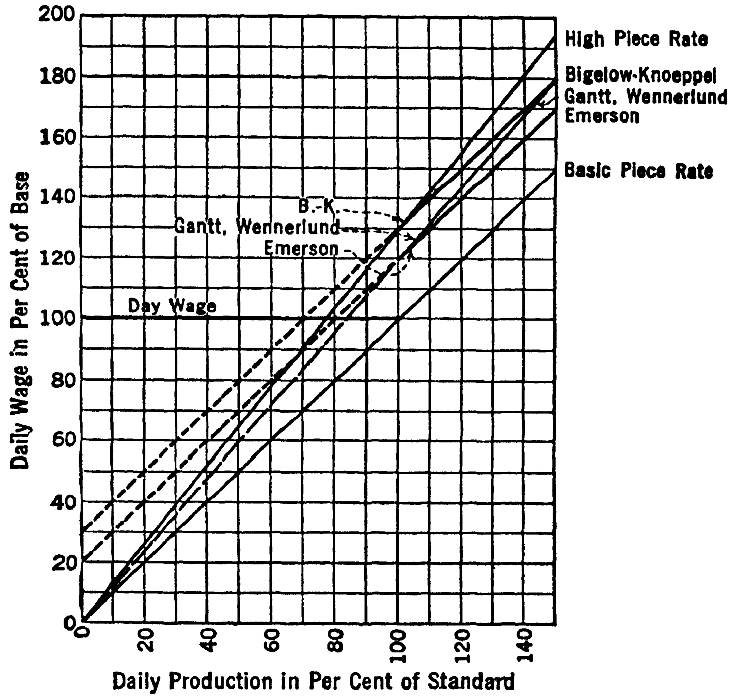


Figure 23. Slopes of Three Empiric and Three Piece Rate Plans Above Task

the Parkhurst plan has a different slope for each of his fifteen classes. The original Knoeppel plan is parallel to basic piece rate, but with an additional bonus of 25% above it all the way. This is not as much as the piece rate slope for its starting point (100, 125). The original Bigelow curve is also parallel to basic rate with a 25% bonus in addition above it all the way. The Emerson curve is parallel to basic piece rate with an addition of 20% bonus all the way above task and again less than the (100, 120) piece rate for its starting point. The Bigelow-Knoeppel curve is parallel to the basic piece rate with the addition of a 30% bonus all the way above task. Its starting point is on the high piece rate (100, 130), but it falls away from that by the same characteristic shown above.

All this is important as the empiric plans invariably claim to give more than "piece rate." If basic piece rate is clearly meant by this,

the claim is justified. On the other hand, each curve except that of Wennerlund falls away from the piece rate of its starting point, so that the recipient of the wage certainly does not have a piece rate progress from point to point of production. In short, these slopes, except Wennerlund's, all lack the piece rate characteristic and, therefore, do not keep up in earning as piece rate does from the price paid per unit at task. For more detail see the chapters on the separate plans.

Slopes of Constant Sharing Plans.—For a given arithmetic fraction of sharing, as many of these earning curves can diverge from the vertical intercept point as there are task levels. Halsey (50-50) sharing curve (Figure 24) passes through day wage at the low task, and Diemer (50-50) sharing curve begins 20% above

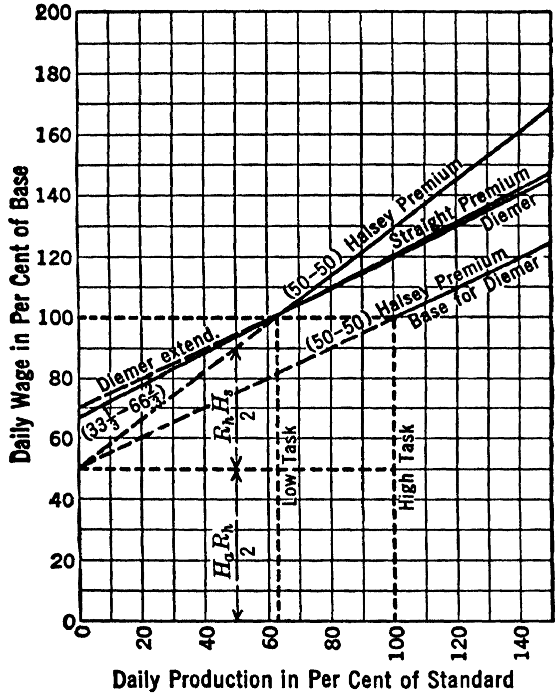


Figure 24. Slopes of Three Constant Sharing Plans

day wage at high task, proceeding parallel to a (50-50) constant sharing line drawn through point (100, 100). These two plans, although using the same (50-50) constant sharing principle, are widely apart in slope. This would, of course, be impossible were it not for the two sets of H_s/H_a or horizontal scales which practice forces us to recognize. As the low slope of constant sharing is designed purposely to keep within reasonable earning range despite the early start of a low task, there is little to be said for such low slope

when it is used to start at the later point of high task. At least, the claim of (50-50) sharing means much less and undoubtedly has deceived those familiar with the Halsey low task plan. This is made doubly clear when we observe that the (33⅓-66⅔)[6] sharing curve passing day wages at low task coincides with the Diemer (50-50) sharing curve at the (100, 120) point, and proceeds slightly above it throughout the remaining production points. In other words, a (50-50) sharing premium plus a bonus of 20%, but based on high task, actually gives less wages above high task than the (33⅓-66⅔) sharing premium with no bonus, but based on low task. The latter is a correct use of the slopes and tasks; the former is an incorrect use of them.

How to Make Low and High Task Plans Comparable.—The sharing or premium plans such as those of Halsey, Rowan, and Barth are designed for the low (62½%) task. In figuring for these plans we must, therefore, take that point of production as task (100%). To permit comparison with the high task plans, two sets of efficiencies are given side by side; the one which puts the 100% back to 62½% of high task is in parentheses. In reality this makes another H_s/H_a or horizontal scale. Time saved or lost must also be figured from the lower standard and is similarly entered in parentheses. It is these parenthetical figures which are used in deriving the earnings, etc.

For example in the (33⅓-66⅔) constant sharing plan,

$$E = (2\,H_a + H_s)\,\frac{R_h}{3}.$$

Assume the point of efficiency = 160%.

#1 Using an 8-hr. Task			*#2 Using an 8-hr. Actual Day*[7]
	8	$= H_s =$	12.8 (160% of 8)
(See Table 36)	3	$= H_s - H_a =$	4.8
	5	$= H_a =$	8
	10	$= 2\,H_a =$	16
	8	$= H_s =$	12.8
	18	$= 2\,H_a + H_s =$	28.8
	\$ .16	$= \frac{R_h}{3} =$	\$ .16
	\$2.88		\$4.61
	1.60	$= \frac{H_s}{H_a}$	No need for prorating
	\$4.61	$= E =$	\$4 .61

[6] The figure given first represents the employee's share.

[7] The following incidentally shows that either H_s or H_a might be taken as the constant.

In the first method we have used the same 8-hour task as in the high task cases, but have here used it as 160% of what was required on the low task basis. Thus, the time saved at this rate of working was 3 hours per 8-hour task.

In the second method we have allowed 12.8 hours for the 8-hour task, making 4.8 hours saved at the same efficiency. It does not matter which way is used. The tables are for the former, and in that prorating is essential to make out a full 8-hour day. Note that a distinction must be made between expressing sharing plans above task in terms of:

(a) 100% of base time wages plus employee fractional share of earnings saved.

Illustration: $E = H_a R_h + \frac{(H_s - H_a)}{3} R_h$ or ($33\frac{1}{3} - 66\frac{2}{3}$) sharing plan

(b) Employer fractional share of base time wages plus employee fractional share of piece rate earnings.

Illustration: $E = \frac{2}{3} H_a R_h + \frac{H_s R_h}{3}$ or ($33\frac{1}{3} - 66\frac{2}{3}$) sharing plan

The Formula Must Also Be Corrected to Conform.—A "Diemer type plan" with step *bonus at 80%* of high task may be used to illustrate the necessity of correcting a formula *on other-than-unity task* derived by adding vertical magnitudes from the chart (Figure 27).

By such addition the formula might appear to be:

$$E = H_a R_h + \frac{3}{10} H_a R_h + \frac{5}{10} (H_s - H_a) R_h$$

$$= \frac{5}{10} H_s R_h + \frac{8}{10} H_a R_h \text{ (as per unity task, viz., putting 1.0 at .8)}$$

A special H_{sl} must, however, be used because one of the points determining the position of the 50-50 sharing has the abscissas value of .8 rather than unity and any point x on the earning curve above "task" must include all values back to this other-than-unity task, viz.:

$$H_s = \frac{10}{8} H_{sl}$$

Substituting this equivalent in the above formula:

$$E = \frac{5}{10} \left(\frac{10}{8} H_{sl} \right) R_h + \frac{8}{10} H_a R_h$$

Thus, $$E = \frac{5}{8} H_{s1} R_h + \frac{8}{10} H_a R_h$$

Which checks with the slope derived:

$$m = \frac{130-80}{80-0} = \frac{5}{8}$$

Hence a change in abscissas scale changes slope *numerically,* in this case from 5/10 to 5/8.

Interpretation by Graphics.—All of these matters become more clear when checked by the graphs. For instance, the share and the labor-saving coefficient, the E intercept representing the former and the coefficient of $(H_s - H_a)R_h$ representing the latter, are identical so long as the earning curve in question passes the (100, 100) point. Otherwise they are not the same. The E intercept, in terms of $H_a R_h$, is independent of the H_s variable. While the intercept always indicates the employer's share of wage saving, and while a change in earning slope for the same intercept cannot affect this share, such change does alter the point of intersection between the earning curve and the 100% standard wage line. In the matter of earnings that is the *"actual task position"* regardless of its relation to the 100% efficiency point or *"nominal task position."* On the other hand, an insert of a constant bonus, some per cent of $B H_a R_h$, affects both the share and the actual task position but without affecting the slope. These conditions explain why it is possible to retain a given share while changing the slope and actual task by extending the earning curve through a higher bonus point. The intercept is unchanged but the coefficient of the wages-saved-binomial, which includes the H_s variable relative to nominal task, is changed. Hence the latter coefficient and the fraction of share, or intercept, will not be identical unless the earning curve slope is taken according to the given abscissas scale. See Figure 53 and accompanying comments.

Let us now take the well-known Gantt task and bonus plan and subject it to graphic analysis. First, on the time earning basis the formula in an expanded form is:

$$\begin{array}{cccc} & \text{Item 1} & \text{Item 2} & \text{Item 3} \\ E = & H_a R_h + & .2 H_a R_h + & 1.2\,(H_s - H_a)\,R_h \end{array} \qquad (1)$$

The heavy line in Figure 25 is the earning curve. Note the immediate jump or step bonus at task so that no earning falls between 100% and 120% base wage.[8]

8 When drawing an earning line it is best to make no vertical connection where there is a step bonus because there is no earning between the lower and higher locations.

If we take any point on the curve above task (H_s/H_a) as shown by X we can build up the vertical or (E) distances. First we recognize (item 1) $H_a R_h$ as the height from the origin to the 100% base wage line. Next, we recognize (item 2) $.2 H_a R_h$ as the height from the latter horizontal to the 120% earning horizontal. That leaves (item 3) $1.2 R_h (H_s - H_a)$ for the height between the 120% earning horizontal and the piece rate earning curve.

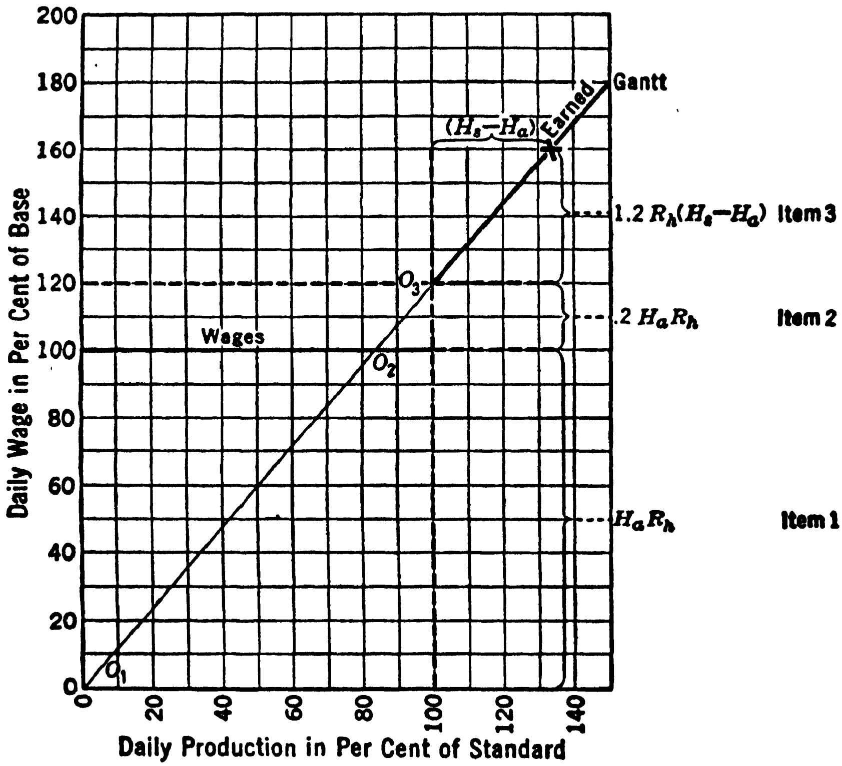


Figure 25. Gantt Formula in Terms of Day Wages and Wages Saved (item 3)

Now, if we change the origin to position O_2, all we need do is to drop off the corresponding vertical magnitude (item 1) $H_a R_h$. The equation becomes for origin at O_2

$$E = .2 H_a R_h + 1.2 R_h (H_s - H_a) \qquad (2)$$

Similarly, drop off corresponding vertical magnitude (item 2) $.2 H_a R_h$. The equation becomes for origin at O_3

$$E = 1.2 R_h (H_s - H_a) \qquad (3)$$

From this position we may scrutinize the curve without the complexities of extra (E) heights upon which the Gantt curve is finally built. Putting (3) into Type B formula,

$$\frac{E}{H_a R_h} = 1.2\left(\frac{H_s}{H_a} - 1\right)$$

We can now identify the slope (m) as 1.2. This is a 20% steeper slope than the basic piece rate. We can also identify the saving variable as ($H_s - H_a$), which means that the saving gained is equal to the height of the earning curve above the bonus.

Going through the same process on the standard hour basis, we rewrite the formula so that basic piece rate may be isolated.

$$\begin{array}{ccc} & \text{Item 1} & \text{Item 2} \\ E = & H_s R_h & + .2\, H_s R_h \end{array} \qquad (4)$$

Here (item 1), (Figure 26), is basic piece rate, and the remaining (item 2) is the additional height of the earning curve above basic piece rate. This addition to basic piece rate $.2\, H_s R_h$ contains the variable H_s so that the earning curve cannot be parallel to basic piece

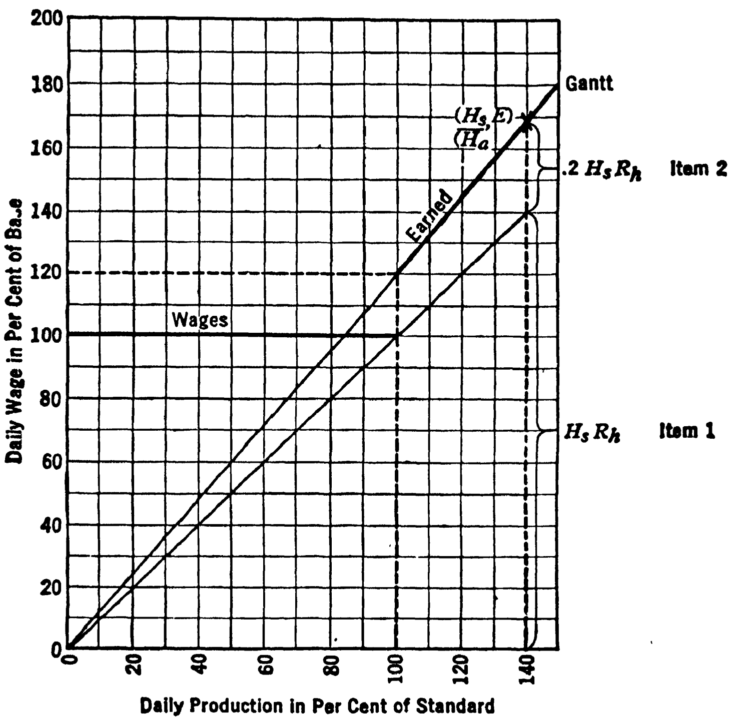


Figure 26. Gantt Formula in Terms of Standard Hours Earned

rate. In fact, these two earning curves are obviously diverging from the origin. At first Gantt used the constant $.2\, H_a R_h$ instead of this variable $.2\, H_s R_h$. In that case his earning curve was parallel to basic piece rate and always $.2\, H_a R_h$ vertically above it. A caution concerning this method of building formulas is given again in connection with Figure 54.

Intersection Between Earning Curves.—In comparing two earning curves it is often helpful to know just where they would intersect if at all. This may be ascertained by taking the two formulas and equating them to solve for the value of efficiency when the earnings are identical.

For instance the Type B equation of the Gantt plan is

$$\frac{E}{H_a\, R_h} = 1.20\,\frac{H_s}{H_a}$$

and that of the (33⅓-66⅔) constant sharing plan is

$$\frac{E}{H_a\, R_h} = .53\tfrac{1}{3}\,\frac{H_s}{H_a} + .66\tfrac{2}{3}$$

Equating and solving for H_s/H_a we get 1.00, and putting that value back in either equation we find that $E/H_a\, R_h$ equals 1.2, that is, they intersect on the 100% efficiency line or at point (100, 120).

Bonus and Premium Defined.—*Bonus* is that portion of earning, expressed in per cent (B_o) of guaranteed wages, $B_o\, B\, H_a\, R_h$, which at some fixed efficiency point exceeds the earning, B% of time rate $B\, H_a\, R_h$ arranged for preceding efficiency point.[9] It may be offered as an abrupt "step" or in a series of steps for predetermined points of efficiency attainment. These vary in size and number from a single large step, as used by Taylor, to 32 minute steps portrayed in a "bonus-efficiency" table, as used by Emerson. The same quantity also occurs, usually unrecognized, in all high piece rates where it is the measure of excess earning over base wage at the high task efficiency, remaining constant while premium increases for higher efficiencies. This "bonus" is a matter of mathematics only and may be included in premium by considering $B = 1.0$ instead of 1.2 or whatever is paid at task.

Premium is that portion of earning, expressed in some function (P_r) of wages saved, $P_r\,(H_s - H_a)\,R_h$, which exceeds B% of time wages.[10] If the coefficient (P_r) is numerical and more than, or equal to, unity we have a piece rate plan. If it is numerical but less than unity we have a constant sharing plan and the coefficient measures the employee's share of potential saving. See paragraph "Interpretation by Graphics." If the coefficient is an algebraic variable we have a variable sharing plan. In all cases where there is a bonus at task the premium, if any, continues as a variable in addition to the

[9] B usually equals unity.

[10] When task or base is other than unity, coefficients for H_s and H_a will not be identical.

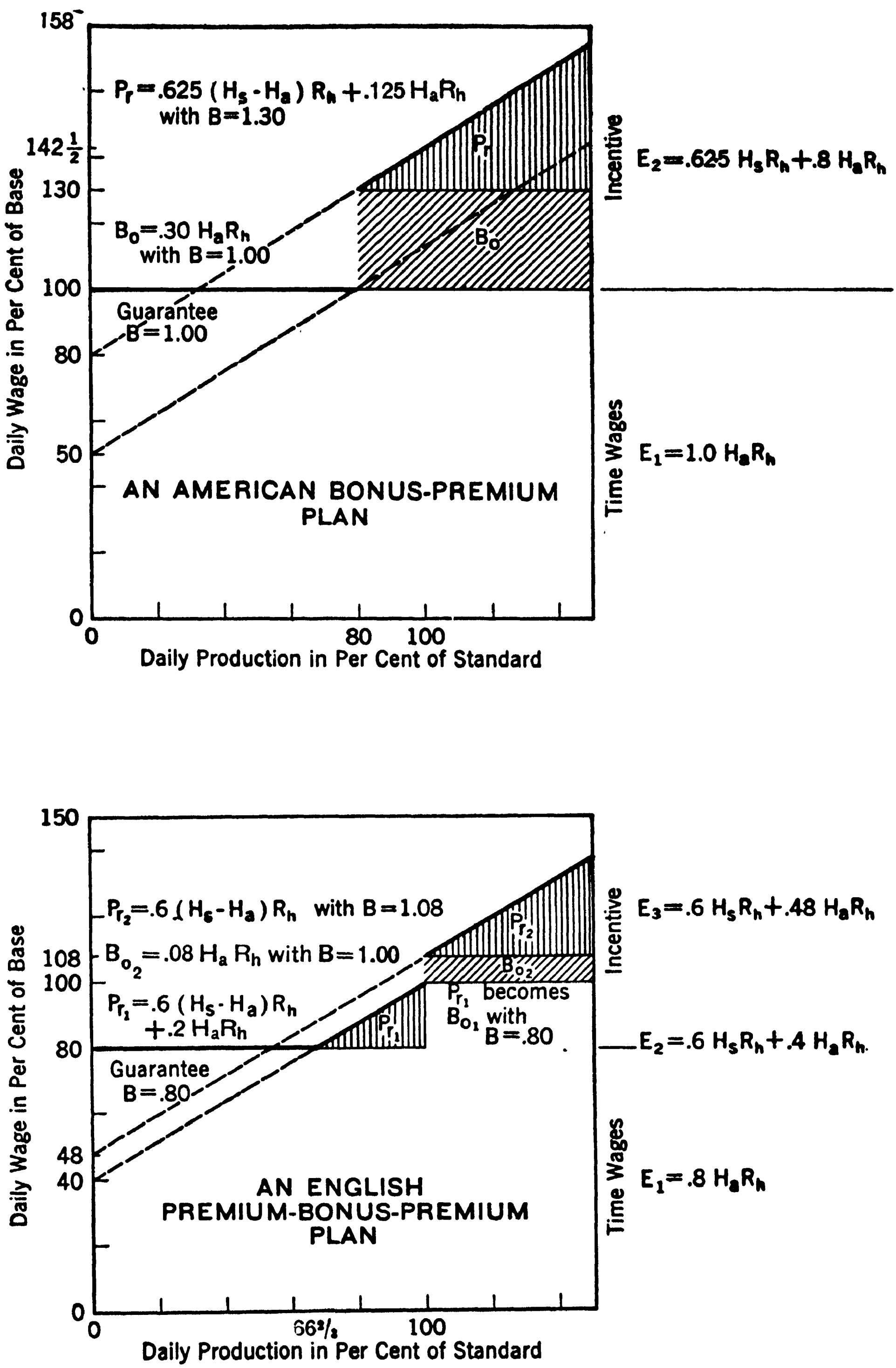


Figure 27. Two Examples of Premium and Bonus Plans (See Chapter 10)

constant bonus but the two are not usually separated in the pay envelope nor on the chart. They can be separated on the chart or by formula for purposes of analysis and comparison. The combined amount of constant bonus and variable premium will be designated as *incentive.*

$$I = B_o B\ (H_a R_h) + P_r\ (H_s - H_a)\ R_h. \quad \text{(See Figure 27.)}$$

General Formula.—This derives the general formula for any earning (E), as shown by its earning curve,

$$E = B\ H_a R_h + I, \text{ or } E = (B + B_o B)\ (H_a R_h) + P_r\ (H_s - H_a)\ R_h$$

and when $P_r = B + B_o B$, the plan is a piece rate, $E = P_r H_s R_h$. Note that the $B\%$ of $H_a R_h$ is a reference level which in some cases may be relocated for different presentations of Bonus and Premium without altering the design.

For instance, in a straight constant sharing plan, as the one charted in Figure 50, the formula will show premium throughout the whole range of efficiency but it just is not sensible to present it as such until total earnings exceed base time wages. Until then it is a loss or penalty to the employee. Hence we impose unity, or a near unity B, on the $H_a R_h$ which may be used as the foundation above which premium becomes a superstructure. For further study compare Figures 65 and 86.

In most formulas B, B_o and P_r will become numerical constants, and hence all three symbols (B, B_o and P_r) will commonly disappear.

Earning Curve a Fixity Between Two Variables.—We have now seen that a wage plan is, first of all, a mathematical fixity between two variables. We find that it can be reduced to exact formula and that the formula can be manipulated to isolate day wage, premium or bonus, as well as slope and intercept. Thus we are able to make comparisons in regard to any of these phases. By this process we see that a sharing plan, properly used, may be more generous than a piece rate plan for certain efficiencies and that a piece rate plan may be made "too good to be true."

When we remember that both the task location, and the time wage level are subject to change, we realize that almost any position on the chart may be reached by one or the other type of slopes. We cannot, however, safely give a high earning for low production on any piece rate plan, and we are not likely to give a high earning for high production by the less than unity slopes of the constant sharing plans.

As to the choice of the hour term in the formulas, we considered

that the best expedient to aid simplicity. Any formula in the book can, however, be changed to the minute term by substituting

$$\frac{M_s}{60} = H_s \qquad \text{and } \frac{M_a}{60} = H_a$$

where M_s = Minutes standard
and M_a = Minutes actual

If it is desired to translate any formula into terms of *hours earned* instead of dollars earned, divide the equation by R_h. Thus the Diemer formula

$$E = \frac{R_h}{2} H_s + \frac{7R_h}{10} H_a \text{ will become } \frac{E}{R_h} = \frac{H_s}{2} + \frac{7H_a}{10}$$

Examples of Plans.—A search by mail was made among progressive companies for examples illustrating the various plans. Such material is bound to be lacking in uniformity and is hardly susceptible to much interpretation. A brief questionnaire was used to indicate the kind of material desired and to secure some uniformity for the sake of comparison. (See Appendix D.)

CHAPTER 5

CLASSIFICATION OF INCENTIVE PLANS

Facts when justly arranged interpret themselves.—BEVERIDGE.

Former Classification Unsatisfactory.—At first it was usual to classify incentive plans according to the bases such as production incentives, quality incentives, material economy incentives, service incentives, etc. These so-called bases were then subdivided into time payment plans, piece rate plans, contract plans, bonus or premium plans, etc. The trouble with that method is that many plans are partly on one base and partly on another, so that the number of exceptions makes the whole classification confusing. There are also more fundamental considerations. If classification does not clarify and give orderly arrangement, it is worthless. We shall, therefore, attempt a classification which can fulfil its nominal purpose.

General Classification for All Incentives.—There are two divisions as to general characteristics which concern major policies of management. We shall call these two divisions policy A and policy B. Policy A is that of immediate stimulation of effort emphasizing the "star" performance, and is usually adaptable to the small, non-continuous processes. Policy B is that of long-run stimulation of teamwork, emphasizing organization performance, and is usually adaptable to large, continuous processes. Henry S. Dennison, president of the Dennison Manufacturing Company, has made a classification,[1] Table 19, according to these two major policies and has subdivided each one into seven subdivisions which occur as contrasting conditions of those policies.

Discussion of General Classification.—The two divisions of this classification designated as policies A and B provide us with a choice of two extreme strategies. It is possible to follow both policies A and B in some respects by using two plans separate in purpose, but harmonious in application. For instance, any one of the financial incentive plans may be used under policy A on individual production,

[1] This classification was given as a paper before the Winter Convention of the American Management Association, New York City, February 7, 1928, and at that time was put into diagrammatic form by this author.

TABLE 19. CLASSIFICATION OF INCENTIVES BY GENERAL CHARACTERISTICS

Policy A Immediate Stimulation of Effort Emphasis on "star" performance Usually small-scale, non-continuous process	*Policy B* Long Run Stimulation of Teamwork Emphasis on organization performance Usually large-scale, continuous process
1. INDIVIDUAL APPLICATION It is strong but non-cooperative.	1. GROUP APPLICATION It is weak but cooperative.
2. CASH REWARD ("Extra-Financial") It is strong but temporary.	2. NON-CONVERTIBLE STOCK REWARD It is weak but persistent.
3. LOW RATE WITH HIGH BONUS It is strong but does not facilitate hiring. A low rate means a high production task.	3. HIGH RATE WITH LOW BONUS It is steady and facilitates hiring. A high rate means a low production task.
4. FLUCTUATING It is strong but discouraging to some.	4. NEARLY CONSTANT It is weak and bonus considered as part of rate.
5. SYSTEMATIC 6. PUBLIC } Provides advance understanding but requires experience. It avoids jealousies.	5. ARBITRARY 6. SECRET } It allows consideration of the intangibles but causes recipient to guess at what is wanted and to cater for favor.
7. FINANCIAL (See further sub-division)	7. NON-FINANCIAL
⟵ MATTER OF	EMPHASIS ⟶
It is immediate but requires the support of other measures to take care of quality and teamwork.	It is the only way to the correct mental attitude, loyalty, etc., but must be backed up financially.
This division is older and less experimental.	This division is newer and more experimental.

and some plan for publishing production records may be used as a nonfinancial incentive, a policy B item. Whether or not there are separate plans to accomplish both policies A and B, it is permissible to zigzag across the two divisions of this classification, Table 19, instead of going straight down on one side through all seven items. For instance, the company policy could include:

B_1 Group bonus
A_2 Cash reward
A_3 Low rate and high bonus (with its corresponding high task)
B_4 Nearly constant
A_5 Systematic
A_6 Public
A_7 and B_7 Financial and nonfinancial combined

The Gantt plan applied to a related group would exactly fit all these conditions. Items B_5 and B_6 are only justified as temporary expedients while experimenting with a new plan and then usually in the case of incentive for executives.

Natural Classification for Financial Incentives.—When we realize that time wages are independent of production and that piece wages are independent of time, it will be seen that there are two different types of financial incentives at the outset. The first, time plans, we will call Class I, in which employer takes all gain or loss relative to standard performance. The second, piece rate plans, we will call Class II, in which employee takes all the gain or loss. As the sharing or premium plans fall between these two, it is necessary to establish Class III, in which the gain is shared between employer and employees. If we now establish a fourth class for the plans eliminated by the three foregoing, we will have Class IV in which there is empiric location of points between two variables. While this class name describes exactly what is done in the plans so classified, it needs to be noted that the empiric points are usually within a certain zone rather than all the way from low to high performance. Finally, we have a new class of plans which, because of continued variation upward, cannot be classed with any of the foregoing. These we have named Accelerating Premiums and add for them a Class V. This natural classification of all financial incentives is given in greater detail in Table 20. Engineers frequently gave their names to the plans which they originated. These have been retained in the Table. (See Figures 28 to 32.)

TABLE 20. CLASSIFICATION OF FINANCIAL INCENTIVE PLANS BY PRODUCTION-EARNING CHARACTERISTICS †

A definite quality, quantity standard must be established and enforced as a prerequisite to any of these plans except I-1.

CLASS I. *Employer Takes All Gain or Loss*

1. Time: hour, week, or any straight salary rate. Not an extra-financial incentive.
2. Standard time using two rates, one either side of task. A two-zone differential time plan.
3. Differential time: arithmetic steps in rate between production zones. (Sometimes called standard time plan.)
4. Differential time: geometric steps in rate between production zones.

CLASS II. *Employee Takes All Gain or Loss*

5. Piece or straight commission rate. This subdivides into: punitive, basic, and high.
6. Taylor (Differential piece rate or differential commission.)
7. Merrick (Differential piece rate or differential commission.)
8. Gantt (Combination of No. 1 and No. 5 with step between.) (Without step would be called piece rate with guarantee, Manchester, Standard Hour, 100% Premium or Haynes Manit, and now Bedaux. All six have identical earning curves.)

CLASS III. *Gain Shared Between Employer and Employee but Day Wage Guaranteed, Excepting in Barth and "One-third Premium" Form of Halsey.*

9. Halsey.* Also Factor plans of Westinghouse.
10. Diemer.
11. Baum.*
12. Bedaux, Dyer, Keays-Weaver, K.I.M., Parkhurst, Shanley, and Stevens.
13. Ficker Time } (Awkward and unsound.)
14. Ficker Piece }
15. Sherman Individual-Group (Awkward and unsound.)
16. Rowan,* Mansfield,* and Bayle.*
17. Barth* (Particularly good for beginners.)

CLASS IV. *Empiric Location of Points Between the Two Variables*

18. Emerson
19. Wennerlund (Piece work or commission above 100% production.)
20. Knoeppel.
21. Bigelow.
22. Bigelow-Knoeppel.
23. Parkhurst (see 12 above).
24. Ernst and Ernst.
25. Sylvester.

CLASS V. *Accelerating Premium from Any Minimum Wage, Through Any Efficiency — Earning Point*

26. Hyperbolic curves, under high piece rate.
27. Parabolic curves, over high piece rate.
28. Mean of above two curves, called Hybrid of *H* and *P*.

† Originally given by the writer before the Marketing Executive's Division, American Management Association at Philadelphia, May 18, 1927, M. E. Series, No. 51.

* Intended for old-fashioned management with low production standards.

Most Financial Incentives Derive from the Same Two Elements.—While the classification just given is both natural and simple, it has to be taken on faith until the plans are analyzed. This analysis requires considerable space, but the results of it may be diagrammed in small space. (See Figure 33.) In this diagram the two elements which are found in nearly every financial incentive plan[2] are placed at the top of the page with arrow lines extending from them and brought together, showing in what manner they are combined to make up the various plans. The formula for each plan is given in its most reduced expression, but can be developed as indicated by simple algebra. In each case the formula is for production above the task only. To read, take for example the Halsey Premium plan: this (time wages) added to ½ this (wages saved) gives (arrow) Halsey Premium plan.

Key to Symbols

E = Earning in dollars (the vertical variable)
H_s = Hours standard (the horizontal variable)
H_a = Hours actual (a constant)
R_h = Rate per hour in dollars (a constant)

Little Essential Difference in Many Plans.—The purpose of the chart in Figure 33 is to indicate how two simple elements are actually combined into plans which seem at first quite dissimilar. This dissimilarity decreases in many cases when the expressions are written as indicated for the Halsey Premium plan by way of illustration. All of these steps are given under the separate plans, and any one wishing to compare any two plans will do well to develop each formula step by step and side by side. The remarkable thing in this simplified presentation is to note how unimportant many of the differences really are. In fact, few of the twenty-five plans completely analyzed in this book have essential or original modifications from the simpler forms. It is to be hoped that the past tendency to diverge from well-established plans will either cease or else new plans in the future will be made so distinctive that they will really serve special purposes. Only "fond parents" would claim this for some of the twenty-eight plans which have been included in this classification.

[2] The exceptions are: Barth Variable sharing and the Accelerating Premium plans.

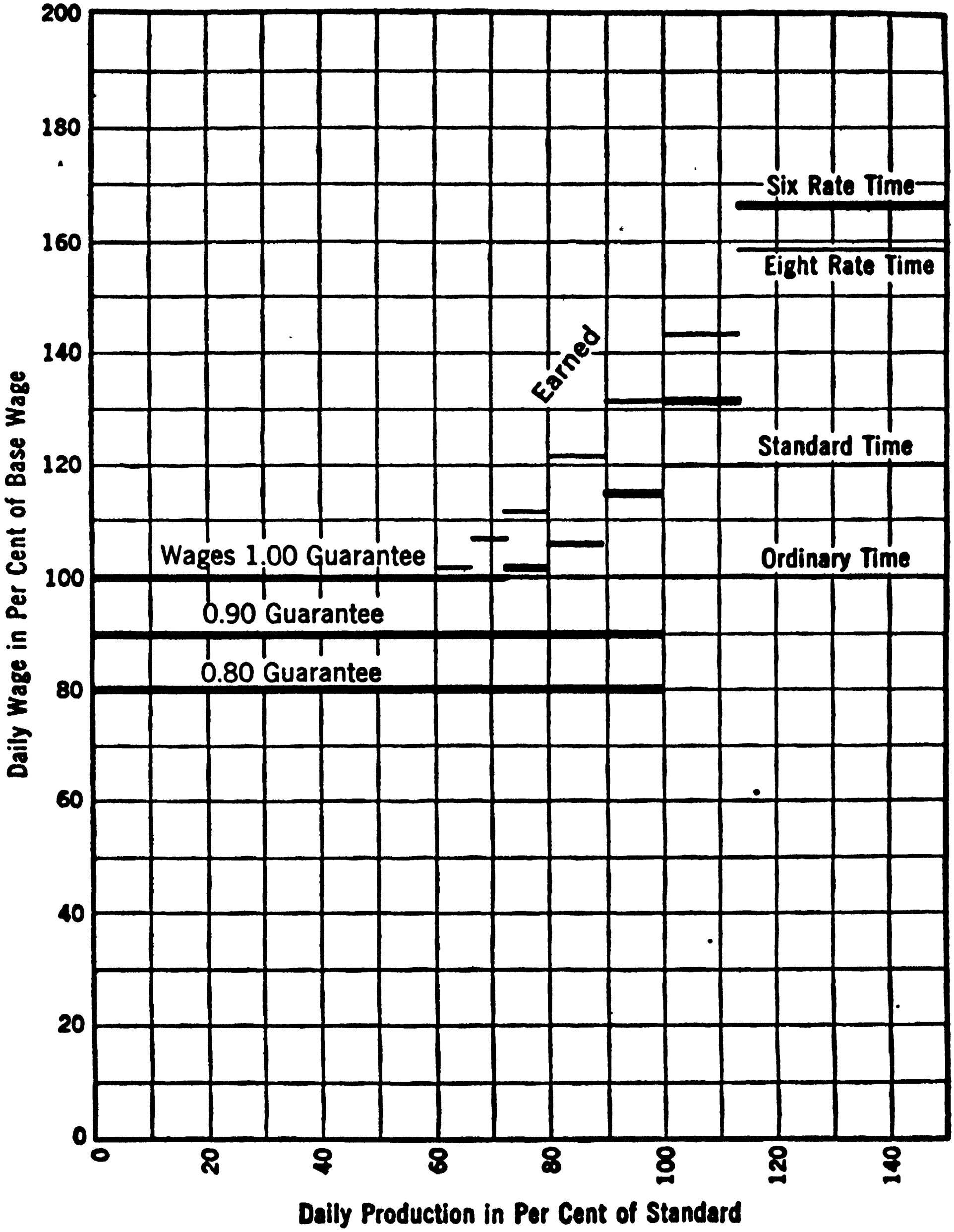


Figure 28. Earning Curves—Class I Plans, Employer Taking all Gain or Loss

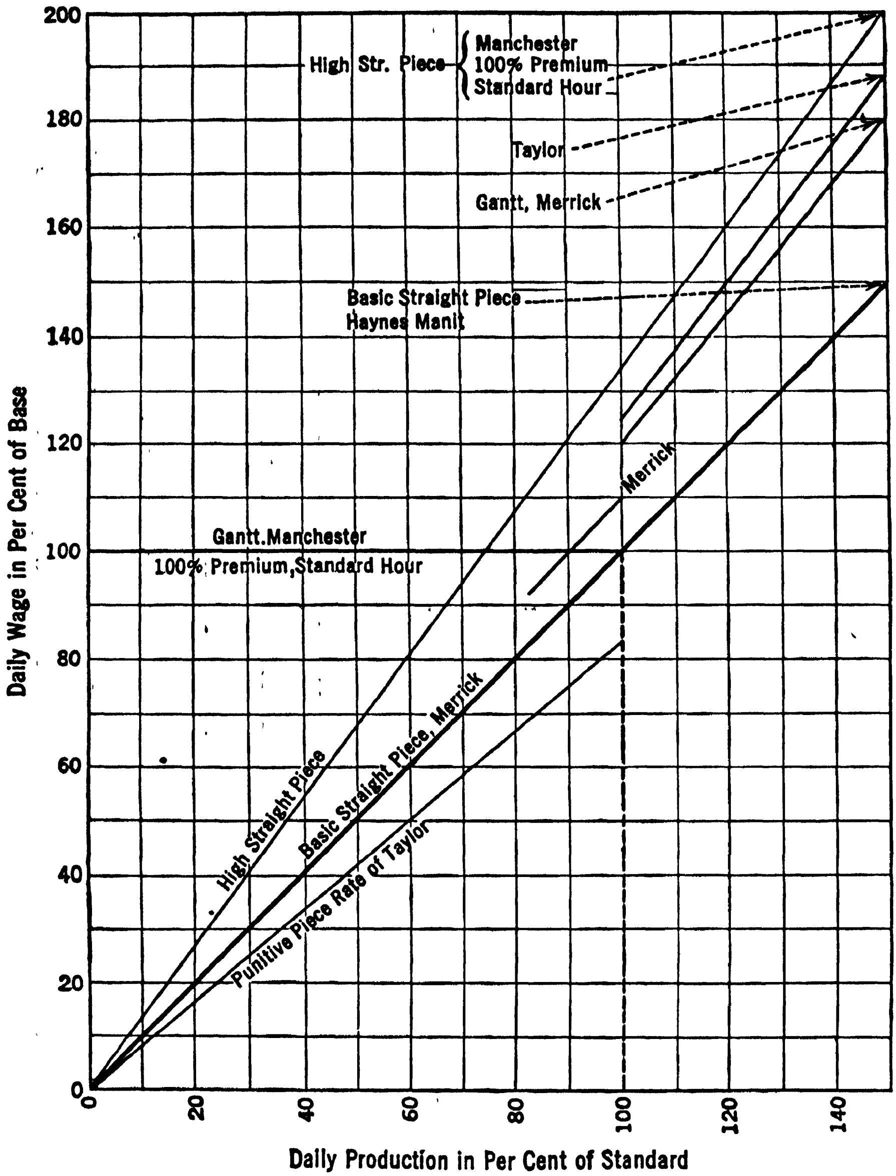


Figure 29. Earning Curves—Class II Plans, Employee Taking All Gain or Loss

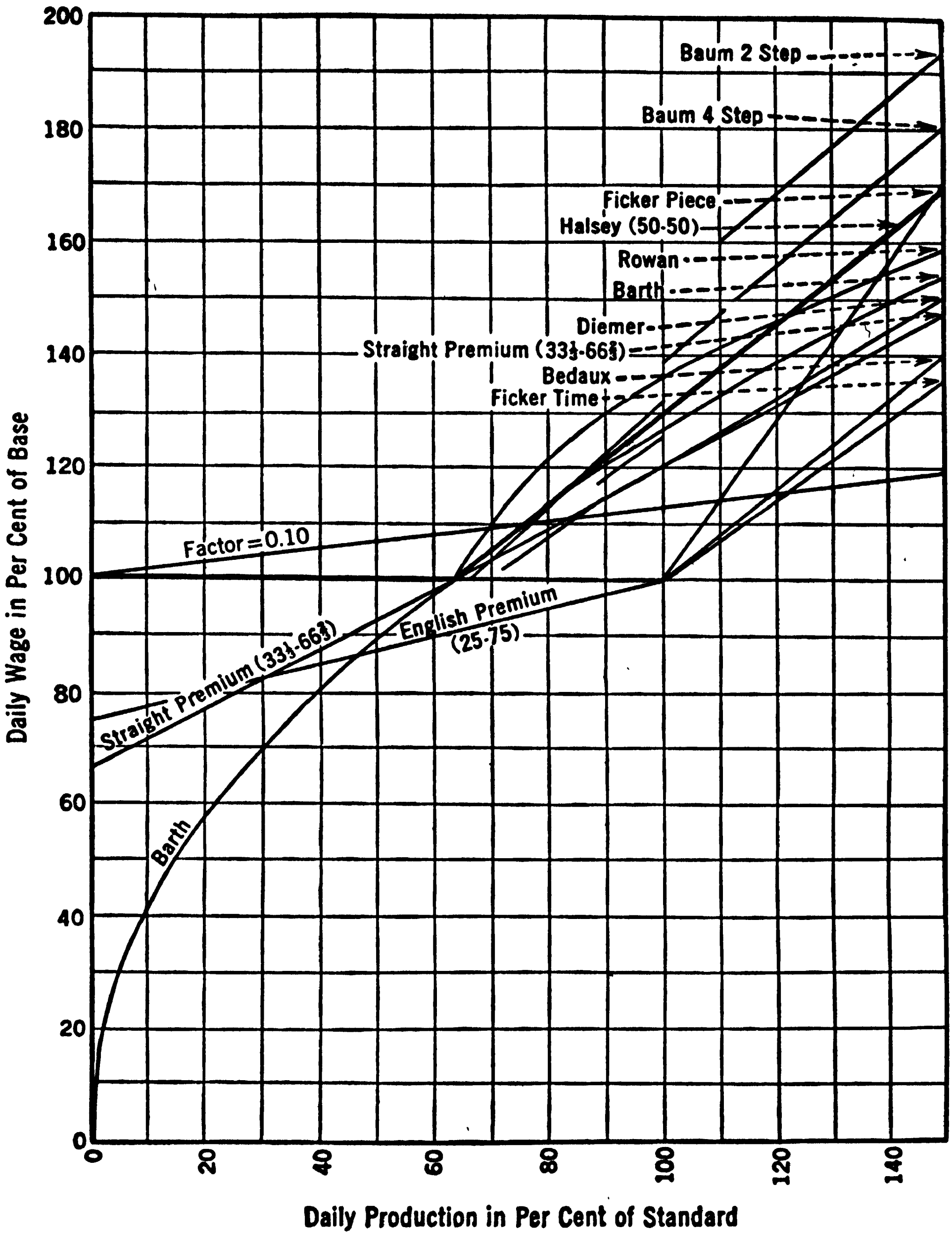


Figure 30. Earning Curves—Class III Plans, Employer and Employee Sharing Savings

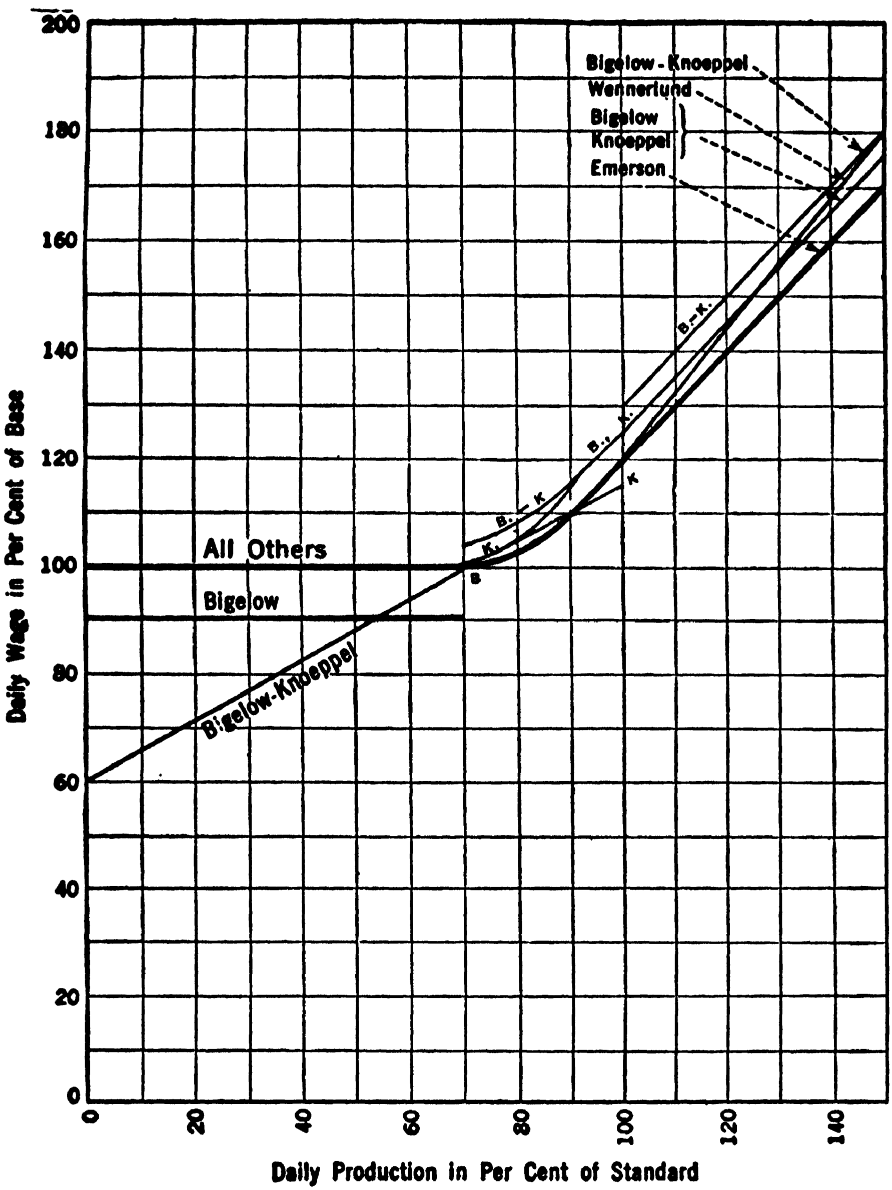


Figure 31. Earning Curves—Class IV Plans, Empiric Bonus-Efficiency

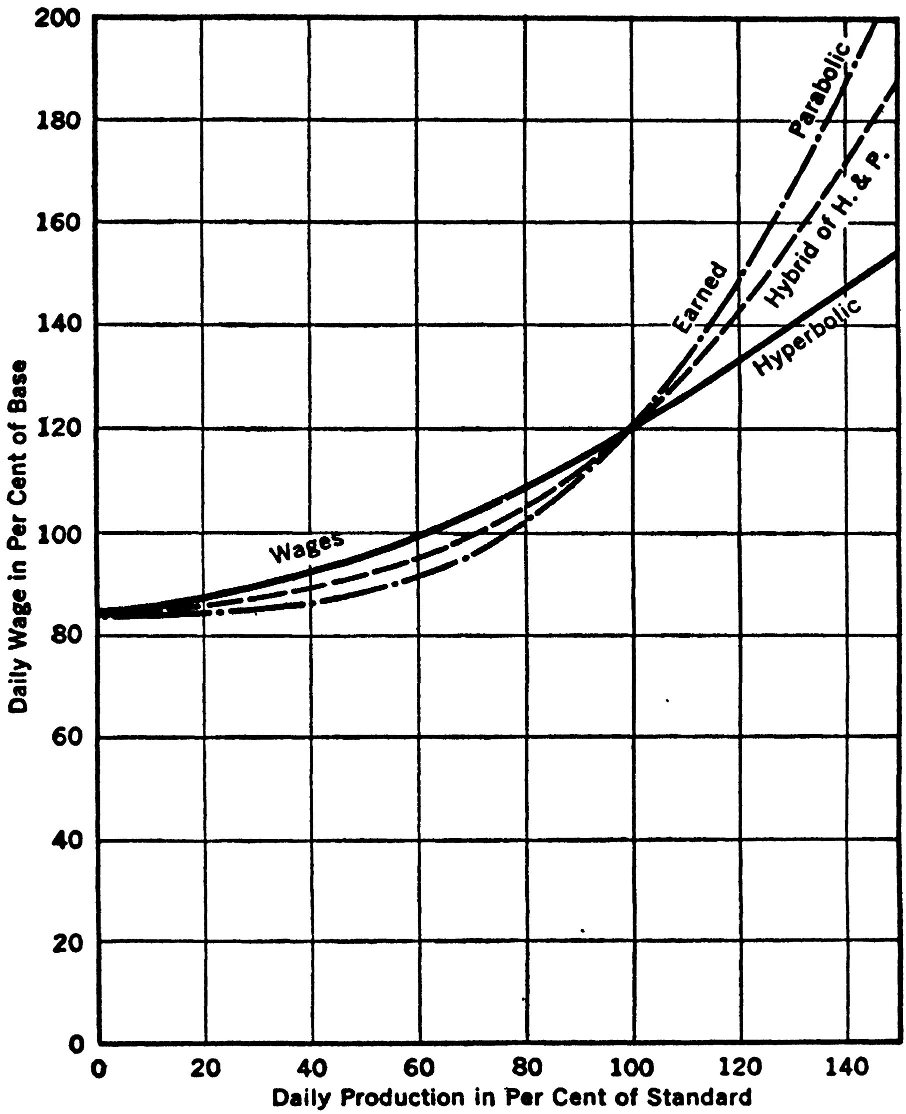
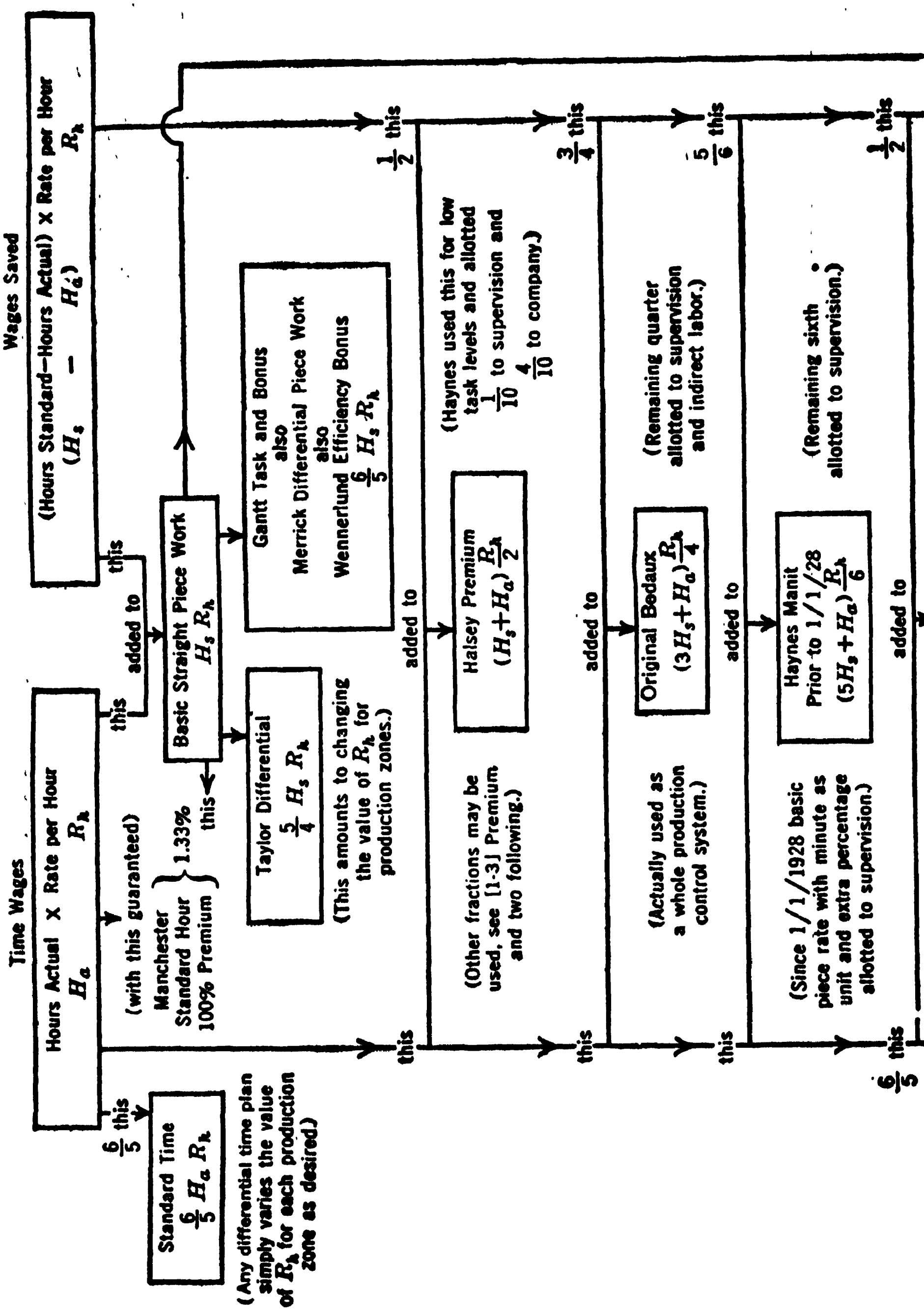


Figure 32. Earning Curves (Class V Plans) Accelerating Premiums
(For others see Figures 79 and 83, Appendix B.)



Time Wages
Hours Actual × Rate per Hour
H_a R_h
(with this guaranteed)
Manchester Standard Hour 100% Premium
1.33%
Wages Saved
(Hours Standard—Hours Actual) × Rate per Hour
(H_s − H_a) R_h
$\frac{6}{5}$ this
Standard Time $\frac{6}{5} H_a R_h$
(Any differential time plan simply varies the value of R_h for each production zone as desired.)
this
added to
this
Basic Straight Piece Work $H_s R_h$
Taylor Differential $\frac{5}{4} H_s R_h$
(This amounts to changing the value of R_h for production zones.)
Gantt Task and Bonus also Merrick Differential Piece Work also Wennerlund Efficiency Bonus $\frac{6}{5} H_s R_h$
$\frac{1}{2}$ this
added to
Halsey Premium $(H_s+H_a)\frac{R_h}{2}$
(Other fractions may be used, see [1-3] Premium and two following.)
(Haynes used this for low task levels and allotted $\frac{1}{10}$ to supervision and $\frac{4}{10}$ to company.)
$\frac{3}{4}$ this
added to
Original Bedaux $(3H_s+H_a)\frac{R_h}{4}$
(Actually used as a whole production control system.)
(Remaining quarter allotted to supervision and indirect labor.)
$\frac{5}{6}$ this
added to
Haynes Manit Prior to 1/1/28 $(5H_s+H_a)\frac{R_h}{6}$
(Since 1/1/1928 basic piece rate with minute as unit and extra percentage allotted to supervision.)
(Remaining sixth allotted to supervision.)
$\frac{1}{2}$ this
added to
$\frac{6}{5}$ this

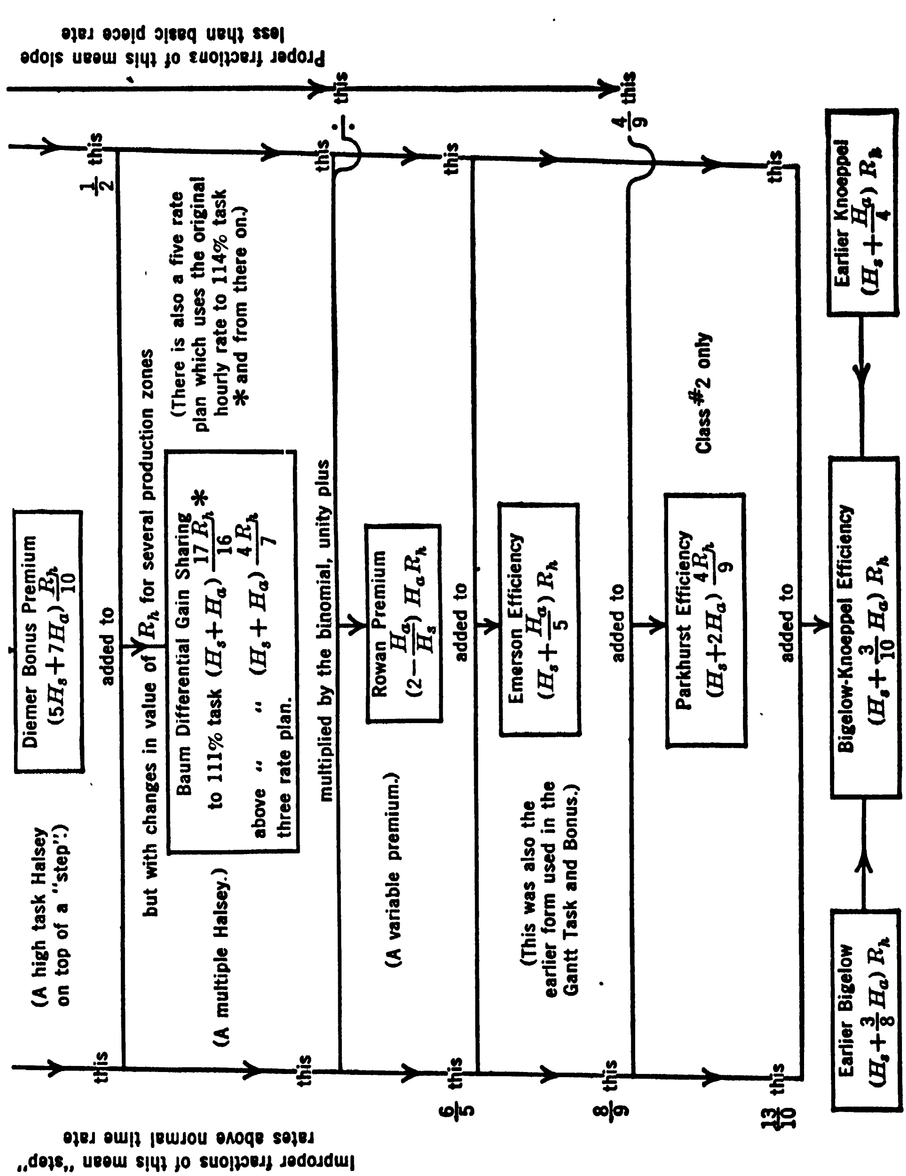


Figure 33. Evolution of Various Plans from Single Quantities. Formulas are for earning above task and are simplified.

CHAPTER 6

TIME RATE PLANS

Men will not do an extraordinary day's work for an ordinary day's pay.—F. W. TAYLOR.

Time Payment a One-Sided Contract.—The principle of employing men on the basis of paying for their time may, or may not, be older than the principle of paying by the job or piece but it is more primitive in its nature. The latter came in cities with the general price system which goes back to antiquity. The former is mixed with the furnishing of food and lodging and is lost in the serfdom of the middle ages where practically all a man's waking hours were required by his manorial lord. Both principles were used by early capitalism, the job price for independent craftwork, and the time rate for practically all noncraft work and for most of the craft work where the men were employees rather than independent merchants. The "factory" units were small and supervision very intimate. Hours were from sun-up to sun-down but the tempo was easy. Neither employee nor employer had thought much about waste-elimination. Hence an arrangement which committed the employer to a definite amount of payment while it failed to commit the employee to a definite amount of production was not only plausible but actually satisfactory. This situation changed little in the United States until after 1840 when larger factory units and the 10-hour day began to emerge. Free land in the United States together with the industrial revolution kept labor scarce and wages relatively high.

Better power for machine production and for railroad transportation gradually made competition something more than local. Thus slowly employers became more cost conscious and tried to solve their economic problem by rate cutting and by driving. One executive of wide experience claimed, as late as 1929, that the efficiency of ordinary day work sometimes went as low as 25% of a high task, that 33⅓% was not unusual, and that 58% to 75% was usual. Thus the time plan became unsatisfactory to both parties concerned. Either the employer had a conception of quantity which was not accepted by the employee, or more commonly, neither had any conception of what constituted a day's work.

Where Time Wages Have Not Been Discarded, They Have Been Improved.—Some are still content to think fallaciously that production is directly proportional to time, and it is natural to cling to so simple a conception, but the standard work day has everywhere shortened while wages have increased tremendously. Either the employer must protect himself by extra provisions for keeping up the quantity or else he must change from the time basis to some other. Companies experiencing severe competition have gradually made the change, mainly to piece rates, excepting under two special circumstances, one where the skill of the worker is high, and the other where the nature of the work is changed constantly, both being difficult to standardize.

It is maintained by many that time wages are necessary for the best quality of product, but the evidence is showing overwhelmingly that this is not the case provided certain other measures of management are in force. For instance, an eastern piano company, pre-eminent in its field for quality, has practically nothing but piece work in its factories. The jobs are standardized, each employee is provided with special tools and fixtures, the rates set are liberal, and every care is taken to carry out maintenance, production control, nonfinancial incentives, etc. Where jobs are changed constantly, it is still difficult to use other plans, but it is being done to a surprising degree at least in the larger companies. In this connection the point principle of payment is one of the solutions, as points may be assigned to all elements of the varying jobs, and the points added as like quantities. The standard hour basis of figuring piece rates has also facilitated the change.

Production Limits.—Curiously, there is at the same time a new factor tending to bring back time wages, although the method of using them is quite different from the earlier loose method. Wherever there is a chain assembly, or an automatic machine, the fair capacity of work is known. In the case of the line assembly, it is imperative that the employee keep up to this capacity. Under such circumstances, the amount of production per unit of time is constantly enforced so that, whether the payment plan is called time wages or piece wages, it is identical in earning but different in character. It should have a new name, such as mechanically paced work. Except for that, the earning through time payment is always independent of the amount of production between the extreme limits of discharge on one side and promotion on the other. It is true that the "public opinion" of employees or the close supervision of the foremen may narrow these limits considerably. This plan is,

therefore, best suited for small departments where the man is more than a mere number to both his comrades and to his supervisor. It is most satisfactory for the higher class of employees who are sure to be energized by ambition or dictates of conscience. This is why salary payment has given less trouble than hourly wages, although identical in principle.

Employer Takes All Gain or Loss.—Any increased productive effort which the employer is able to secure from time paid employees is double gain to the former, and any let down in productive effort is a double loss to him (Figure 33), but in the long run the indefinite contract of the time plan is more detrimental to the ambitious employee than to the employer. At best, both parties suffer under this plan and little can be said in its favor excepting the cheapness of clerical work, such as payroll figuring. Even here, more clerical work is entailed for cost finding than under the piece rate plan. Over many years it has been observed that the typical time paid employee takes nearly twice as long to do a given job as is really necessary. This lost time is of two sorts: (a) avoidable delay, which is clearly the employee's own fault; (b) avoidable delay, which is a matter of poor planning on the part of management. The former may constitute inaptitude, inexperience, loafing, or deliberate restriction. These results are also likely to occur when the time plan is used as a day guarantee in connection with other plans. Prevention of these employee losses are possible in part by employer action through job evalution and other personnel functions. The avoidable delays due directly to loose management may be minimized by improved maintenance of equipment, by carefully planned material schedules, and by incentives for supervision. On the other hand, it is likely that some of this is "unavoidable" delay and will occur even in well-managed plants, so that the time wage used temporarily as a guarantee during such emergencies will always be necessary.

Minimum Wage Guarantee.—The question of adjusting a minimum wage guarantee on the basis of the day or the hour is a matter of policy. The shorter the period used as base the fairer it is to the employee and the greater the incentive for work under a wage incentive plan. Conversely, no incentive plan can have full effect if the extra earnings are made to cover idle time due to causes beyond employee control. The principle involved here is similar to the payment of time and a half for overtime. In other words, the cost should be a penalty on management for allowing delays and when interpreted this way spurs management to keep such delays at the minimum. Taylor, Gantt, and followers always believed in "imme-

diacy," that is, exact and prompt relationship between acomplishment and resulting reward. The Emerson group sacrificed that somewhat by figuring everything on the basis of a week, but with the purpose of encouraging an employee who lost out temporarily through his own fault. Today the best management will prefer to make the adjustment on the hourly basis, even if it takes more clerical work. When that is done one source of real grievance will be eliminated.

With Supporting Measures Time Rates May Still Be Satisfactory.—On the more favorable side, time wages may be used with a large degree of satisfaction, provided some means is taken to connect earning with production indirectly. For instance, the elapsed time on jobs done by trustworthy employees may be recorded, together with the conditions. With these records as a basis, individual records may be kept and compared with accepted records. Where such lists of individual performances are posted, the employee's reputation is more at stake and he usually responds to this non-financial incentive. It is also possible to readjust the rates of pay at intervals and to take into consideration the amount of performance in connection with this adjustment. When this is done regularly and fairly, employees soon learn what is expected for each rate. Nominally, the plan remains the same, but actually it introduces a mild incentive. Under these circumstances, the time wage plan takes on some of the advantages of the more complex plans and at the same time retains the simpler characteristics. Such a time plan is consistent with modern management and may be made effective.

Salary.—This has been defined as "predetermined periodical allowance made as compensation to a person for services."[1] It is nothing more than a time earning, rated and usually guaranteed in full for the longer periods of a week, month, or year. It has the weakness of simple time wages in that the employer must trust the employee to give him adequate returns. For this reason it is best suited to very responsible employees, but is also customary for clerks of the lower grade because their work has been considered impossible of close measurement. Substantial salary implies a trust or partnership and is generally accepted as such. It frees the recipient from immediate worries and is often more than earned.

As to sales work, the salary plan is adequate for routine selling where tasks or objectives cannot be defined and where a salesman must do other work besides direct selling. For instance in food-product lines, the salesman must set up displays, handle collections,

[1] C. K. Woodbridge, Bulletin of the Taylor Society, Vol. VI, No. 4.

and make goodwill calls on the managers of chain stores. Where either long-run development or service is as important as immediate sales, the salary applied to selected "plodders" is the practical remuneration. The rerating principle applies to salary as to time wages and, when used, makes salary a mild incentive. Straight salary is probably used by 50% of all concerns for sales work, but most of these also offer prizes through some form of contest.

FORMULA FOR EARNING:

$$\text{Earning} = \text{Hours per Day} \times \text{Rate per Hour}$$
$$E = H_d \times R_h$$
$$\text{Earning} = \text{Hours Actual} \times \text{Rate per Hour}$$
$$E = H_a \times R_h$$

In case of salary: $E = R_t$ per specified period

Key to Symbols

E = Earning in dollars (the vertical variable)
H_s = Hours standard (the horizontal variable)
H_a = Hours actual (a constant)
H_d = Hours per day
R_h = Rate per hour in dollars (a constant)
R_t = Rate per week, month, or year

Cost per Piece.—As might be expected, the cost per piece under the time plan is invariably high at lower productions. While apparently low at higher productions, the latter are seldom reached, so that the total cost per piece must be considered high unless measures already described are sufficiently successful to secure an unusually large response throughout the department. With such measures it may be the lowest cost plan for intermediate productions (Figure 34).

Applications of Time or Day Rate Plan.—The fact that no company, during our investigation, has sent us any forms illustrating the operation of this plan makes it appear as though no forms are used. Excepting clock cards and job time cards, this is actually the case. We did receive several questionnaire answers all of which referred to: clerks, tool makers, die makers, pattern makers, repair men, electricians, pipe fitters, and janitors. As a guarantee in connections with other plans it has come into new importance on account of the Fair Labor Standards Act.

Establishment of Tasks Alone Provides Incentive.—If the management of a company is willing to keep track of the production

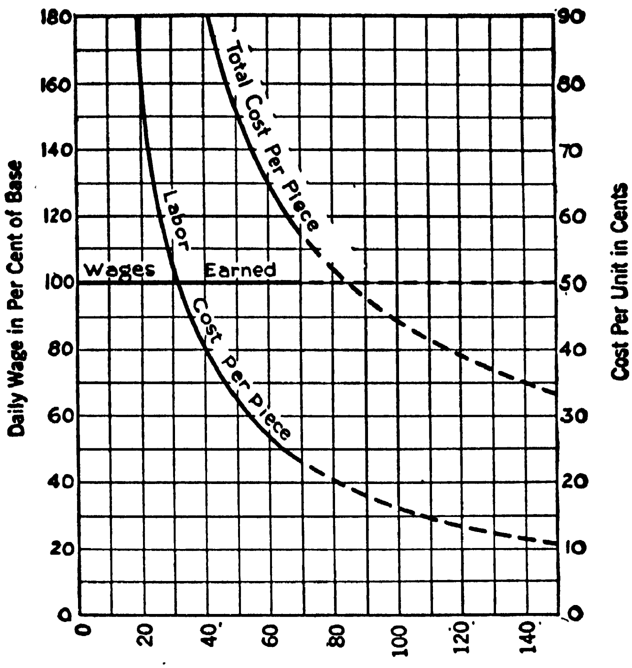


Figure 34. Time or Day Rate Plan Not an Extra-Financial Incentive

TABLE 21. TIME OR DAY RATE DATA

Per Cent of Production H_s/H_a	Per Cent of Total to Base Wage for Full Day $E/H_a R_h$	Total Daily Wage in Dollars E	Number Pieces per Day	Time Saved per 8-Hr. Task in Hours $H_s - H_a$	Labor Cost per Piece in Dollars	Total Cost per Piece in Dollars
0	100	3.84	0	fictitious	3.84*	7.68*
10	100	3.84	2.4	− 72.0	1 60	3.32
20	100	3.84	4.8	− 32.0	.80	1.72
30	100	3.84	7.2	− 18.6	.53	1.18
40	100	3.84	9.6	− 12.0	.40	.92
50	100	3.84	12.0	− 8.0	.32	.76
60	100	3.84	14.4	− 5.3	.27	.66
66	100	3.84	16.0	− 4.0	.24	.60
73	100	3.84	17.5	− 3.0	.22	.56
80	100	3.84	19.2	− 2.0	.20	.52
89	100	3.84	21.4	− 1.0	.18	.48
100	100	3.84	24.0	0.	.16	.44
114	100	3.84	27.4	1.0	.14	.40
133	100	3.84	32.0	2.0	.12	.36
145	100	3.84	34.8	2.5	.11	.34

* Not per piece.

records of individual employees and to make readjustments of rates periodically on that basis, it might as well work out a systematic plan for the procedure. In fact, there is one great advantage in doing so. When an employee fails to make the same production that he has been making, he may resent receiving a lowered rate, although it is entirely justified. If such a reduction is plainly mapped out in advance, he may feel regret but not resentment. Furthermore, employers should not begrudge the cost of establishing tasks, for there is a certain incentive in having a task even where the earning is not a function of it. (See Figure 13.)

Mr. Taylor must have had this in mind when he wrote in 1895, "The system by which the writer proposes managing the men who are on day-work consists in paying *men* and not *positions.* Each man's wages, as far as possible, are fixed according to the skill and energy with which he performs his work, and not according to the position which he fills. Every endeavor is made to stimulate each man's personal ambition. This involves keeping systematic and careful records of the performance of each man, as to his punctuality, attendance, integrity, rapidity, skill, and accuracy, and a readjustment from time to time of the wages paid him, in accordance with this record." Today we would evaluate the jobs to derive correct base rates and then merit-rate the men to derive correct individual differentials to add to the base rates.

"Measured" Day Work.[2]—This plan was devised during the late depression as a compromise between a regular incentive plan and a no-incentive time plan. It sets up an hourly rate per man-job which, in part, reflects the job, and, in part, the worker. For the first part job analysis is used, that is, the requirements of each job are evaluated as to (a) skill, (b) responsibility, (c) mentality, (d) working conditions, (e) physical application, etc. These job measures, in terms of characteristics, determine the amount each base rate must exceed the fundamental base rate. For the second part, or *extra compensation rate* as it is called, a combination of tangible and intangible personal virtues are graded, that is, (a) quantity of production, (b) quality of production, (c) versatility, (d) dependability, etc. These man-measures are weighted by somebody and then applied to increase the various base rates on the average from 1/6 to 1/3. The composite of all this is called the *measured day rate.* Essential to its effect as an incentive is the periodic review and correction either up or down. For beginners this judgment-day is once a month, for others it is usually once in three months.

[2] *Factory,* February and June, 1937, also N. A. C. A. Bulletin September 1, 1938.

Most any wage plan may be good for some set of conditions and no wage plan has ever been best for all sets of conditions. As far back as 1924 we said[3]: "There are several measures which can be utilized to connect time wage with task:

1. Time which elapses on a good performance can be carefully recorded and checked with conditions of performance.
2. All production records can be kept and followed by individuals and foremen. If these two steps are taken and if adjustments in rate are made according to performance, time plan can be fully as successful as many of the more complex plans."

Now the main difference between this and "measured day work" is that the latter is made as complex as the worst of the other plans! Furthermore, this complexity brings in several intangibles. It is hard enough for an employee to face any rate readjustment every three months, but it must be much harder when his fate depends upon the arbitrary grading of some intangibles. Incidentally, the base is shifted from an engineer's job standardization to a personnel man's job analysis, and job analysis cannot consider the technicalities of equipment, tools, methods, motions, etc. Finally, we would prefer to leave the variation of daily earning as far as possible in the hands of the individual employees themselves. Under well-managed incentive plans an employee can blame no one but himself if he falls short of hoped-for earning. Under measured day work he may harbor a real or imagined injustice for months and it would be a *personal* grievance too. We believe, therefore, that "measured day work" does not follow the right principles. It is less impersonal and less automatic than a regular task-based plan.

Standard Time Plan.[4]—The minute a management establishes differential time rates, it introduces the production element because the change from one rate to another must be fixed at some production point (Figure 35). If there are to be but two rates, the change from one to the other should be located at or near the high task point (100, 100). It is called standard time, because the time of work is standardized. The difference in the two rates may be anything. The lower rate is still called the day work rate, and the higher one the standard time rate. The latter applies to all productions at and above task, but in practice, where the task is high, it is rare for employees to go far beyond. While production just above the task point may occur frequently under other bonus plans, it is particularly characteristic of the standard time plan because of its level earning curve, which

[3] *Management's Handbook*, p. 926.
[4] Westinghouse uses this name erroneously for a different plan.

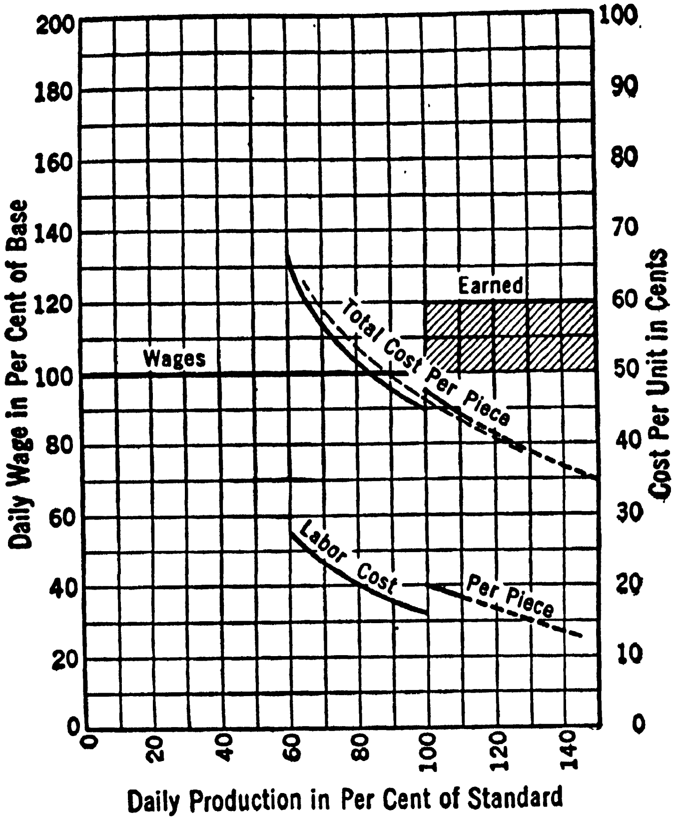


Figure 35. "Standard" or Differential Time Plan, Two Rates

TABLE 22. "STANDARD" OR DIFFERENTIAL TIME DATA, TWO RATES

Per Cent of Production H_s/H_a	Per Cent of Total to Base Wage for Full Day $E/H_a R_h$	Total Daily Wage in Dollars E	Number Pieces per Day	Time Saved per 8-Hr. Task in Hours $H_s - H_a$	Labor Cost per Piece in Dollars	Total Cost per Piece in Dollars
60	100	3.84	14.4	− 5.3	.27	.66
66	100	3.84	16.0	− 4.0	.24	.60
73	100	3.84	17.5	− 3.0	.22	.56
80	100	3.84	19.2	− 2.0	.20	.52
89	100	3.84	21.4	− 1.0	.18	.48
100	120	4.61	24.0	0.	.19	.47
114	120	4.61	27.4	1.0	.17	.43
133	120	4.61	32.0	2.0	.14	.38
145	120	4.61	34.8	2.5	.13	.36

lacks the incentive of an upward slope. Consequently, it fills the need where equipment is both expensive and delicate, where a good production, but no more, is wanted.

When the increase in rate is as high as 20%, this plan provides a strong incentive, at least for task, and is as much a bonus plan as any of the other step plans. There are never more than two figures of earning for any individual. The payroll and cost figuring are simple. Many employers like this plan because it allows employees of different hourly rates to work at the same work with no just complaint of different wages. The justice of this is questionable, but there may be cases where it is hard to avoid.

FORMULA FOR EARNING:

Earning up to high task = Hours Actual × Rate per Hour

$$E = H_a \times (R_h)_1$$

Earning at and above high task = Hours Actual × Standard Time Rate

$$E = H_a \times (R_h)_2$$

Where $(R_h)_2 = 1.20(R_h)_1$

Cost per Piece.—Below task the costs for the standard time plan are identical with those for ordinary time plan. At task the total cost per unit is about with that of the Diemer, Merrick, Gantt, and Emerson plans. Above task it would be still lower than these plans, but average production is not likely to be maintained far above the task point. The main interest is, therefore, the task cost which is one of the lowest. Since a cost curve is for the whole group concerned, the effect of the rate change in the earning curve is here not abrupt. There may be individual producers on both sides of the rate change and net cost is the average for all individuals. We have, therefore, shown a curve representing the mean of the two cost conditions.

Example of Standard Time Plan.—This plan, minus immediate automaticity, is used by a mid-west company which manufactures special applications of fractional horsepower motors. It does not have quantity production of standardized parts and is, therefore, like a jobbing plant.

Despite the handicap of many small orders, there is special tooling and layout to manufacture parts in a progressive system. Standardized time is allowed for the output of these special pieces and whenever the operator increases his output over the standard hourly rate and maintains it for two weeks, his hourly rate is increased accord-

ingly. By this means the factory operator has an incentive to produce an extra number of pieces per hour and, in turn, he is compensated by receiving a larger rate per hour. Of course, the company stands to lose if it is obliged to transfer an operator from his regular work to another kind of production, but it is not obliged to do this except in times of slack business. It is working satisfactorily, and every one earns on the basis of his results and ability. If the increased rate of work is not maintained, the employee is set back to a lower hourly rate. There are about 100 employees on the plan.

Differential Time Plan, Six Geometric Rates.—This plan, Figure 36, we designed in April, 1925, to illustrate how time rates could be made to do all that the more complex plans could do. While it is aimed particularly at sales work, it is no different in principle from the standard time plan. It is slightly more complex to figure but not at all difficult to understand. Instead of having one production location at which rates change, it has five such locations. The height of these rates and their distances apart in production are a matter of design. It seems best to have the production zones, as they are called, smaller at low production. This lends encouragement early in the development. Step bonuses of increasing magnitude are then provided since it becomes increasingly difficult to do the higher and higher productions.

If N, number of units, is the task, it is harder to do $N + 1$ units and so on. Therefore, the increasing amount of the bonuses is consistent with the difficulty involved, and an average curve drawn through the geometric rates gives an earning curve of increasing slope and approaches the ideal incentive. (See Figure 18 also see Accelerating Premium plans.) We have already explained why such geometric or preferred number series are fundamentally correct for human activities. The use of step bonuses instead of a continuous earning curve is a matter of psychology and simplicity.

FORMULA FOR EARNING: (Six Geometric Rates)

Earning = Hours Actual × Rate per Hour

Up to 73% of task	$E =$	H_a	$(R_h)_1$
From 73% to 80%	$E =$	H_a	$(R_h)_2$ or $(R_h)_1 + 1$
From 80% to 89%	$E =$	H_a	$(R_h)_3$ or $(R_h)_2 + 2$
From 89% to task	$E =$	H_a	$(R_h)_4$ or $(R_h)_3 + 4$
From task to 114%	$E =$	H_a	$(R_h)_5$ or $(R_h)_4 + 8$
From 114% on	$E =$	H_a	$(R_h)_6$ or $(R_h)_5 + 16$

This is a bonus rate added to the hourly rate of base day wages.

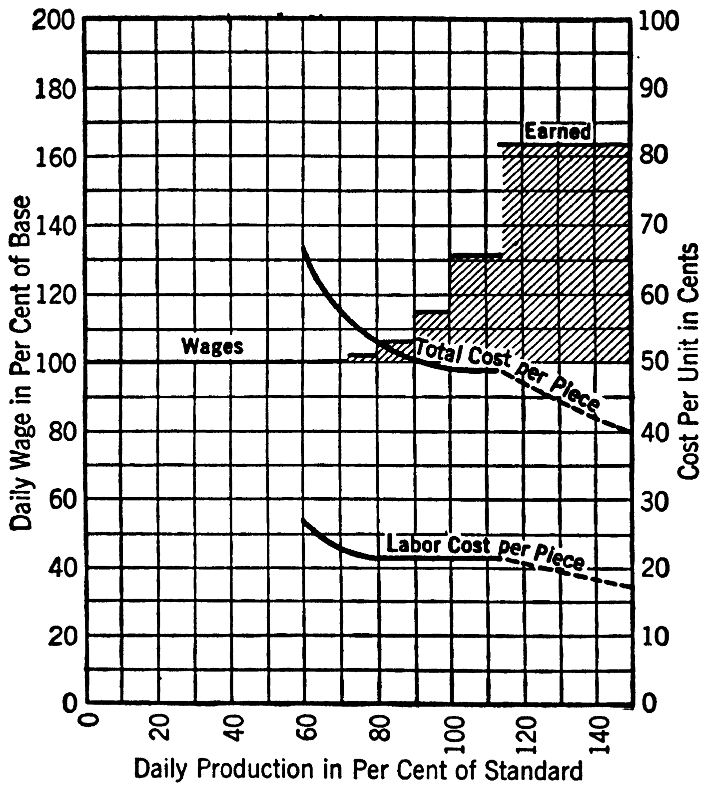


Figure 36. Differential Time Plan, Six Geometric Rates

TABLE 23. DIFFERENTIAL TIME DATA, SIX GEOMETRIC RATES

Per Cent of Production H_s/H_a	Per Cent of Total to Base Wage for Full Day $E/H_a R_h$	Total Daily Wage in Dollars E	Number Pieces per Day	Time Saved per 8-Hr. Task in Hours $H_s - H_a$	Labor Cost per Piece in Dollars	Total Cost per Piece in Dollars
60	100	3.84	14.4	− 5.3	.27	.66
66	100	3.84	16.0	− 4.0	.24	.60
73	102	3.92	17.5	− 3.0	.22	.56
80	106	4.16	19.2	− 2.0	.21	.53
89	114	4.48	21.4	− 1.0	.21	.51
100	131	5.12	24.0	0.	.21	.49
114	165	6.40	27.4	1.0	.23	.49
133	165	6.40	32.0	2.0	.20	.44
145	165	6.40	34.8	2.5	.18	.41

Cost per Piece.—While the cost curves of the six geometric time rate plan are actually in steps, the curve plotted here ignores these steps and shows the mean of them. As pointed out elsewhere, this is correct as far as the employer is concerned, because there are always individual producers on both sides of any rate change and the true cost for any group of employees would never change suddenly as it would seem to do, and as it does for the individual employee. Note the flatness of the total cost curve through the probable range of average response. It is high, but sure of fulfilment.

Differential Time Rates with Efficiency Scale.—A mid-west company manufacturing capsules and elixirs uses the efficiency scale in connection with a multiple time plan in order to focus attention on the efficiencies at which the rates change. There is nothing novel in this as such scales may be used with any incentive plan. The amount of rate increase is 16⅔% between 55% efficiency, approximately average day production, and 100% efficiency. For instance, for a base rate of $.48, the scale would be about as in Table 24.

TABLE 24. EFFICIENCY-TIME RATE SCHEDULE

Per Cent of Efficiency	Rates in Dollars	
1–55	.48	
56–59	.49	
60–69	.50	
70–79	.51	Additional bonuses are paid on the Emerson plan
80–89	.52	
90–99	.54	
100– and above	.58	

Salary with Bonus Applied to Salesmen.—The time plan under the name of salary applies to many kinds of work the production of which varies greatly in quantity or is considered unmeasurable. The amount of sales comes under the former category. The importance of sales volume makes it desirable to use some form of compensation which may be made to depend on the volume. Straight salary alone should not be used widely for sales work, but as a minimum guarantee or "drawing account" it is very common. One of the best means of giving the salesman a strong incentive to volume is to arrange a schedule between volumes and time rates. This is called salary with bonuses, but might accurately be called differential salary plan. It is exactly like the differential time plan except that there are sometimes more rates established. This is because a salesman frequently can secure large orders in the same time and with scarcely more work than that required to secure smaller orders. The chart

becomes extended on both variables so that the "roof is taken off." This well-known fact has made sales work appeal particularly to the "go-getting" type that prefers the chance of large earning to either security of work or gradual promotion. Another form of the differential time rate plan for sales is the practice of paying an extra month's salary at the end of the year to those who meet an advance quota. A large soap company has been doing this with success. For every 1% above the quota, the salesman is given an additional 1% of a month's salary.

Differential Time Plan Applied to Retail Sales.—A well-managed retail store has been readjusting the salary rates for sales clerks every two months since 1910. Sales quotas are established for all departments. In each department total salaries for the past six months are divided by total sales to ascertain the average cost of selling. The average weekly sales of each salesperson are computed and multiplied by the department rate to find what each one has earned. If the sales of an individual warrant a higher earning, the salary rate is increased accordingly and a new quota is assigned. If the individual has not earned the higher rate, it is not reduced, but the recipient is interviewed and shown the record. After a second failure, the employee is transferred for a new trial. If he does not improve, dismissal follows. Where sales volume is seasonal, a whole year is used for the measure. Besides this series of quotas and time rates, bonuses are paid for sales above the departments' average selling per cent for the corresponding period of the preceding five years. The plan has given mutual satisfaction in both good and poor years and has been copied by other managements.

Time Plan with Graded Rates.—A small leather belting company has for eighteen years used a time plan with graded rates. The plan closely parallels the six rate plan already analyzed, except that the steps are more equally spaced as to wage increments and with decreasing ranges of production rather than the reverse. We prefer the psychology of the "six rate" plan. The work involves a fairly high degree of skill and an expensive raw material. The employees are obliged to change frequently from one operation to another. Careful job standards are determined and individual production records kept (Tables 25 and 26). From the latter the periodic rate adjustment is made.

The month percentage rating in each operation is obtained and multiplied by the number of hours applied on that operation; then after adding the figures from all operations and dividing by the total number of hours, the percentage rating for the month is derived.

The employee is not demoted or advanced for one month's showing above or below a class, but if a consistent change is indicated over two or three months, a change in rate is made. A rather complicated cost system gives performance on each job in the different operations, so that in addition to making occasional time studies, the actual performances on a large number of units in different jobs by different men may be obtained. The plan might not be ideal for all plants or conditions, but according to the management: "We find it works better and with less friction between departments and individuals than various other plans we have tried."

TABLE 25. TIME PLAN WITH GRADED RATES

	Rates		Minimum % Rating	Minimum Units per Hour Operation 134–43 A
	Week (47-hr. week)	Hour		
Class 1	18.00	.3830	Below 60%	Under 22
Class 2	20.00	.4255	60%	22
Class 3	22.50	.4787	80%	30
Class 4	25.00	.5319	100%	37
Class 5	27.50	.5851	115%	43
Class 6	30.00	.6383	130%	48
Class 6 Special	35.00	.7447	Over 130%	Over 48

TABLE 26. INDIVIDUAL OUTPUT RECORD*

Date..........................

OPERATOR.........John Jones.........CLASS...5th...STANDING...84.95%...

Dept.	Operation	Output per Hour	Hours	Percentage
134	43-A	30.96	10	72
	"	35.69	100	83
	"	43.43	20	101
	"	36.55	70	85
			200	84.95%

* All based on one operation with average standard for a 5th class man at 43 pieces per hour.

CHAPTER 7

PIECE RATE PLANS WITHOUT STEP BONUSES

Production furnishes the true measure of wages.—F. A. WALKER.

Piece Work Similar to Working by the Job.—Andrew Carnegie, writing of his native village, Dunfermline, Scotland, at the time of his boyhood in the 1840's, said that weaving was done mostly by men who owned their own looms, got webs from the large manufacturers, received *piece rates* and were not tied down to regular hours.[1] For centuries the same principle had been followed in independent craftsmanship, viz., working by the job. While we no longer use this term for the work of an independent maker, yet the present general character of piece work is similar to that of job work. The piece rate operator no longer owns all his own tools, and rarely works under his home roof, but he may still do more or less as he sees fit because the amount of work per unit of time is usually not specified. We do have, occasionally, cases of low grade operators doing so little on piece rate that they are discharged. The discharge is not because of the labor cost per piece, but because of the machine rate, floor space, etc., which go into total cost. Weeding out is, therefore, always necessary in connection with piece rates.

On the other hand, we have many piece rate operators who do more than is good for them. In this instance they may be promoted to more responsible work, but are likely to be kept at the one kind of work at which they excel. In the case of women employees in particular, it is to the employer's interest to advise some to stop short of excessive production, that they may keep up work without experiencing ill health or nervous breakdown. There is another aspect of piece rates which is similar to independent job work. The piece

[1]The original contract type of compensation was not like present piece work in that the employee was both laborer and merchant, while the employer was both merchant and user. He varied his price paid for home labor as market conditions changed, so that the sum paid under contract was far from constant and did not amount to a definite wage per piece as true job work or modern piece work does. The only vestige of this practice, outside of convict labor, is in mines, shipyards, locomotive shops, and silk mills. An employer contracts with a boss to do a section of work, like the assembly of a valve gear. The former furnishes all materials and tools and the latter furnishes the men. The boss may, therefore, gain or lose under each contract, as he is able to get the men to produce more or less than he estimates. It is nefarious in that equipment is neglected and excessive pressure thrown on the men. It did furnish a good training school for some of our captains of industry.

rate operator is anxious to have a steady flow of work coming to him from the previous operation and to have the work as well as the tools and machines in the best condition. He feels that anything short of normal conditions is due to improper management, which it usually is. With justification, therefore, he "steps on the heels" of management and to a limited extent may actually drive the management. In most cases management is alert to this possibility, takes the proper steps to prevent avoidable delays, and allows temporary time payment for unavoidable delays. If management is not so prepared, piece rate or any other strong incentive will be an unfair method of payment and will cause labor troubles.

Unions Demand Efficiency Management.—For the first time in history a union, the Dress and Waist-makers Union, has taken the initiative and forced five dress manufacturers' associations of New York City to adopt an "Efficiency Code" as follows:

1. All bundles given to workers must contain all the parts necessary for the complete sewing of the garments, including accessories and findings, such as zippers, thread, and seam bindings.
2. Proper and adequate instructions shall be given to the workers by qualified foremen or supervisors.
3. Adequate floor service shall be provided with girls taking and returning parts of unfinished garments to workers and delivering garments to workers performing the next succeeding operation.
4. Equipment and machinery shall be maintained in good working order, with machines oiled each week outside of regular working hours.
5. The management shall arrange to have related crafts cooperate in expeditiously completing intermediate or incidental work on parts requiring such handling.

Additional investigation is required before establishing regulations for price ranges above $10.75[2] and standards for ventilation, lighting, and working space for each worker.

Hence the two bargaining groups have together organized the New York Dress Institute to carry on a one million dollar annual program of research. The collective bargaining agreement provides machinery for hearings before an impartial chairman. By this "joint management" it is hoped that the "85,000 workers will not have to waste time but can increase their earnings without increasing the unit costs of production."

[2] Wholesale price per garment.

Straight Piece Work.—If the earning steps of a differential time plan on the standard chart were made on the basis of individual production units from zero up, and were made equal in amount, we would have a series of minute steps approaching a straight line earning curve, always beginning at the origin which is, of course, piece rate earning. We have approximately this in some applications. The terms straight piece rate then means a constant rate of pay per unit of work properly produced and for all units from zero[8] up. Any such arrangement is piece rate, whether the rate is little or much. The straight line slope (Figure 37) directed toward the origin is the essential thing. Conversely, any straight line earning which does not go to the origin is not straight piece rate and any that does not point to the origin is no variety of piece rate.

Although the various piece rate plans are more commonly used than all other plans combined and in the main are more generous, there have been more objections to straight piece rate than to any other one plan. The objections have come from early abuse of the plan and consequent misunderstanding of it. One objection is based on alleged overwork, but the chief objection is to rate cutting. As long as employers felt that any individual should not exceed a certain earning for his trade or operation and as long as time study was unknown, rate cutting was inevitable under any incentive plan used during those times. Older operators have all experienced or known of this rate cutting as a result of some individual exceeding a certain amount of earning. In the clothing industry at one time, piece rates became mere pittances and the term sweatshop still clings to homework in that industry, though that practice is now disappearing.

Effect of Early Piece Rates on Employees.—As far back as 1776 in England, Adam Smith wrote: "A carpenter in London, and in some other places, is not supposed to last in his utmost vigor above eight years. Something of the same kind happens *in many other trades, in which the workmen are paid by the piece; as they generally are in manufactures.*" This upper limit of earning, not stipulated but always evident from the cuts, was quickly recognized in all cases. It was common for employees to work up to a point just below this amount, at which they would stop for fear of a cut. Referring to this tendency, Taylor pointed out that the very worst kind of "soldiering" usually occurred under piece rates. New employees were always advised by the old employees just how far they could go without inviting a cut. Of course, this was of interest to

8 This extreme is now illegal but it rarely was in effect anyway.

all employees in a department because a lower rate per piece, which meant a higher task for the same earning per day, might come to any individual of the same occupation when jobs were reassigned. As employers began to realize the economic principle of high production for a given overhead, they soon learned that rate-cutting was equivalent to "killing the goose that lays the golden egg." Most employers were perfectly willing to give up their older ideas on upper wage limits, but a vexing problem arose as to guaranteeing a rate without subjecting themselves to payment of rates set too high.

Effect of Piece Rates on Employers.—The piece rate, despite its independence of task, has, therefore, been a powerful factor in influencing employers to make careful time and motion studies of all jobs before the standardization of rates. Some employers still feel that it is impossible to set rates so that employees cannot run away with the earning. While it is true that time study analysts may on occasion be fooled by employees working slowly during the study, it is practically impossible for an employee to succeed in this if the analyst is competent. The modern way is to take great pains with the establishment of job standards and rates and then to guarantee no change in either until the job is altered in method. There are still a few employers who wish to avoid the cost of such careful standardization. Readjustment of all tasks and rates at the end of a six months' period, or a year, is sometimes practiced instead of giving a real guarantee, but at best it is giving a postponement of the issue and does not result in whole-hearted release of production. Rate cutting can occur under any plan and is not avoided by doing away with piece rates. The answer to the rate-cutting objection to piece rates is simply, do not cut *any* rates. Like all other plans, there may be great variation in the rates applied to different jobs and if the equalization of rates for like classes of work is not carefully worked out, the higher rate jobs will be greatly in demand and the lower rate jobs will cause much discontent. The problem of task-rate guarantee has again come into prominence on account of the rapidity of change which characterizes present development. There are some who advise setting tasks deliberately high or rates low to play safe for the future. We do not advise this practice because it approaches guess work, and is likely to give wrong tasks present and future. It is far better to set the fairest task and rate possible today and then frankly explain the developments which require a change in task and rate tomorrow.

Piece Rate with Time Guarantees or the Manchester Plan.—Even with a high piece rate, the new employee or the apprentice is

likely to be discouraged. The practice of combining a time guarantee with piece rate, while desirable as a temporary expedient, removes the negative stimulus which is as powerful as the positive stimulus for mature producers. It, therefore, weakens a piece rate plan. With this in view, a day guarantee lower than the usual time rate is occasionally used. On the other hand, the better employees are not likely to fall back on such a guarantee and if the production control is at all weak, the full day guarantee is necessary to make the employee feel sure of a fair wage. For delay due to no fault of the employee, many employers guarantee a rate based on the employee's previous average earning. There are two other names for this plan —one, the standard hour plan, and the other the 100% premium plan. The latter would be more accurately named the 100% constant sharing plan. For earning curves and data, see the time wage plan (Figure 33) up to 75% of high task; and the high straight piece rate plan (Figure 38) above 75% of high task.

Standard Hour Plan.—The standard hour plan means that the piece rate above task is figured on a standard hour basis ($E = H_s R_h$) rather than on piece basis ($E = N_p R_p$). It matters little to the employee whether his wages are figured on the number of standard hours or the number of pieces. For instance, if the rate per piece is \$.10 and the task per standard hour is 5 pieces, on the piece rate basis it would be figured as follows: 5 pieces times \$.10, or \$.50. On the standard hour basis it would be figured as one standard hour at \$.50. The standard hour basis throws the emphasis to the number of hours rather than to the number of pieces. It also avoids the need of the same pay throughout the department for the same work, because each employee may have his own time rate; the only thing common is the number of pieces per hour. While the standard hour method of figuring is often justified for bookkeeping reasons, the practice of paying different individuals different amounts for the same work is questionable. Such virtues as seniority, loyalty, and cooperation are better recognized by stock ownership, vacations with pay, and promotion. Those who object to piece rates because they think it impractical to set rates on all kinds of petty operations, may have the full advantage of the piece rate plan on this basis. Minor operations are combined and may even be timed in over-all quantities or total completions. Thus the task is established in terms of standard hours of work and the rate is applied as the rate per standard hour. No matter what time is taken, the employee is paid for the number of standard hours' work he has produced. This, of course, is giving him all of the labor saving or piece rate. It remains true,

however, that most employees wish to know their earning per piece and will figure it when it is withheld. The time method of figuring a payroll removes some of management's objections to piece rate and facilitates its use for varied production, such as jobbing. The use of the minute as the time unit furthers the same advantage. The Haynes manit plan comprises these features.

Decimals of the Hour.—Similarly, one hundredths of the hour may be used as a time unit for piece rate tasks. A well-known meat packing company has used this plan applied to groups since 1921. In 1929 it had 1,700 men and 300 women on the plan constituting the entire payroll. 120% is cited as the typical efficiency.

"Each employee has a guarantee occupation hourly wage rate, and, whether he meets standard or not during the time he is on the payroll, is paid the wage rate the occupation carries. The employee is paid in direct relation to effort after meeting the task, namely, 1% rise in efficiency is compensated for by 1% rise in earnings. All compensations are made and recorded in fractional (decimal) parts of an hour. That is, 'if the task be 100 pieces and 105 pieces are produced, the employee's compensation becomes 105% of his occupational wage rate."

In a paper box company, the task is always the number of actual hours worked times 100 units or points. After points are once established for all jobs, the point serves as a common denominator for measurement and greatly facilitates production control. The weekly payroll computations are also simplified.

100% Premium or 100% Sharing Plan.—The term 100% premium comes from the fact that piece work allows the employee *all* the labor saving which he makes. It is really interpreting piece rate in terms of premium above time wages and, by the very definition of piece work, the employee receives 100% of this premium. When we fully realize the generosity of this 100% premium, which is an integral part of all piece rate plans, we must admit that the piece rate principle is one of the soundest. Furthermore, it is easy to understand and simple to figure no matter how the rate is fixed. As will be noted in the chart, the direct labor cost per piece is constant and allows the simplest cost figuring of all plans. If we wish to have the full advantage of the piece rate, we must avoid both rate-cutting and time guaranteeing[4] because in either case the piece rate plan may degenerate to time wages. Rate cutting produces this effect on the upper side of production, time guaranteeing on the lower.

4 Except for unavoidable delay and legal minimum, the latter usually too low to concern incentive workers.

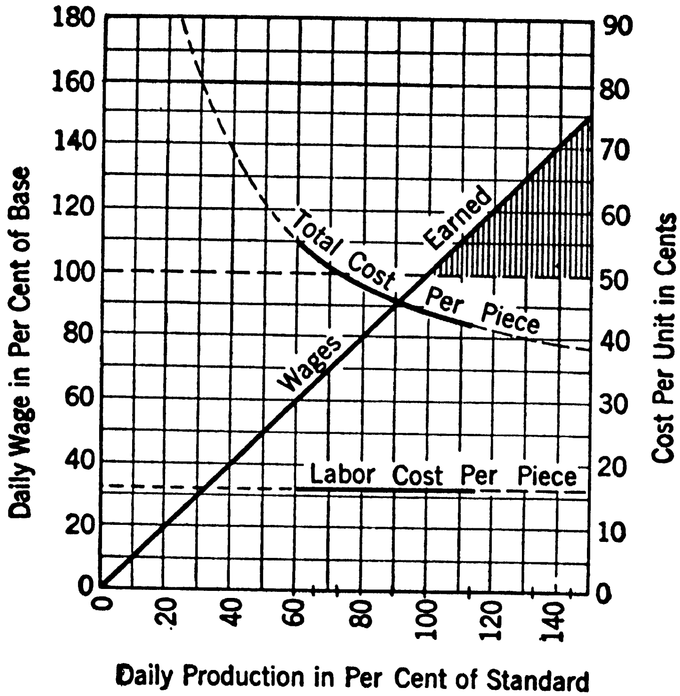


Figure 37. Basic Straight Piece Rate Plan

TABLE 27. BASIC STRAIGHT PIECE RATE DATA

Per Cent of Production H_s/H_a	Per Cent of Total to Base Wage for Full Day $E/H_a R_h$	Total Daily Wage in Dollars E	Number Pieces per Day	Time Saved per 8-Hr. Task in Hours $H_s - H_a$	Labor Cost per Piece in Dollars	Total Cost per Piece in Dollars
0	0	0	0	fictitious	0*	3.84*
10	10	.38	2.4	− 72.0	.16	1.88
20	20	.76	4.8	− 32.0	.16	1.08
30	30	1.15	7.2	− 18.6	.16	.81
40	40	1.54	9.6	− 12.0	.16	.68
50	50	1.92	12.0	− 8.0	.16	.60
60	60	2.30	14.4	− 5.3	.16	.55
66	66	2.56	16.0	− 4.0	.16	.52
73	73	2.80	17.5	− 3.0	.16	.50
80	80	3.07	19.2	− 2.0	.16	.48
89	89	3.42	21.4	− 1.0	.16	.46
100	100	3.84	24.0	0.	.16	.44
114	114	4.38	27.4	1.0	.16	.42
133	133	5.12	32.0	2.0	.16	.40
145	145	5.56	34.8	2.5	.16	.39

* Not per piece.

Curiously, under the conditions of mass production, piece rate earnings also become equivalent to time wages, but with enforced rate of production. The employee must keep up with an automatic machine or a chain assembly, the capacity of which is fixed for a unit of time, and failure to keep at the constant mechanical rate may result in discharge. Some writers have heralded such time payment as a great improvement over piece payment, but except for the enforced tempo it is still piece rate.

FORMULA FOR EARNING*: (Basic Piece Rate)

$$\text{Earning} = \text{Number of Pieces} \times \text{Rate Per Piece}$$
$$E = N_p \quad R_p$$

Since hours allowed for all pieces $= H_s$ and by definition,

$$H_s = \frac{\text{Piece rate earning}}{R_h}$$

$$H_s = \frac{N_p R_p}{R_h}$$

$$\therefore \text{Piece Rate Earning} = \text{Hours Standard} \times \text{Rate Per Hour}$$
$$N_p R_p = H_s \times R_h$$

The latter expression is piece rate earning on the hour basis. If to the expression:

$$\text{Earning} = \text{Hours Standard} \times \text{Rate per Hour}$$
$$E = H_s \quad R_h$$

we add and subtract $H_a R_h$,

$$E = H_a R_h + H_s R_h - H_a R_h$$

Separating the last two terms into a binomial

$$E = H_a R_h + (H_s R_h - H_a R_h)$$

Bringing the R_h outside the binomial

$$\text{Earning} = \text{Time Wages} + \text{Wages Saved}$$
$$E = H_a R_h + (H_s - H_a)\, R_h \text{ (premium form)}$$

This defines piece rate in an illuminating way. It shows us that the employee receives, in addition to time wages, all wages saved due to his working in less than task time. The expression is in the same form as the sharing formulas where some fraction other than unity precedes the binomial or wages saved.

* For key to symbols see page 105.

Since straight piece rate shows no demarkation at any task many managements have found it effective to express piece rate as:

$$\text{Earning} = \text{Time Wages} + (\text{Efficiency} - 1) \times \text{Time Wages}$$

$$E = H_a R_h \quad + \quad \left(\frac{H_s}{H_a} - 1\right) H_a R_h \text{ (bonus form)}$$

This separates the earning which is in excess over unity time wages and can be called and understood as a bonus for work beyond task. It must be remembered, however, that even here the task conception is academic because it means the efficiency when piece rate earning equals unity time rate earning which varies with the slope of the earning curve.

Cost per Piece.—The total cost per piece under basic piece rate is higher for high productions than under the ordinary time plan, but higher productions are actually reached under the former, whereas they are hypothetical under the latter. It is commonly believed that savings due to greater distribution of overhead belong exclusively to the employer, because the employee has little to do with the measures which make such distribution possible. If this is true, then conversely all the saving allowed under piece rates belongs exclusively to the employee, because his effort and skill are independent of the management. It is good psychology to follow these two principles. Any form of piece rate complies with this practice. Finally, it should be understood that even with low earning slopes, piece rates give greater earning increments between production increments than most other plans without bonus steps, and even here, under the differential piece rate plan, the bonus steps may be as high as those of any other plan. The total cost per piece is below the average for all plans and the incentive strength is above average.

High Piece Rate, Straight or with Day Guarantee.—When the rates are set by the piece, $E = N_p R_p$, the amount of work constituting task may not be evident to the employee or to the foreman. The latter does have an idea of the minimum amount which he can tolerate and a good rate setter always knows what the correct task is. The employees will usually have task amounts in mind, but when set by themselves vary from bench to bench. As modern high piece is designed to give from 135% to 120% of the prevailing time rate at "high task," the intersection of the high piece rate earning curve with the unity time rate line should lie between 74% and 83% efficiency. This incidentally encourages those who have stabilized productivity below that range under the day wage plan. Some ordinary day rate employees average as low as 42% of high.

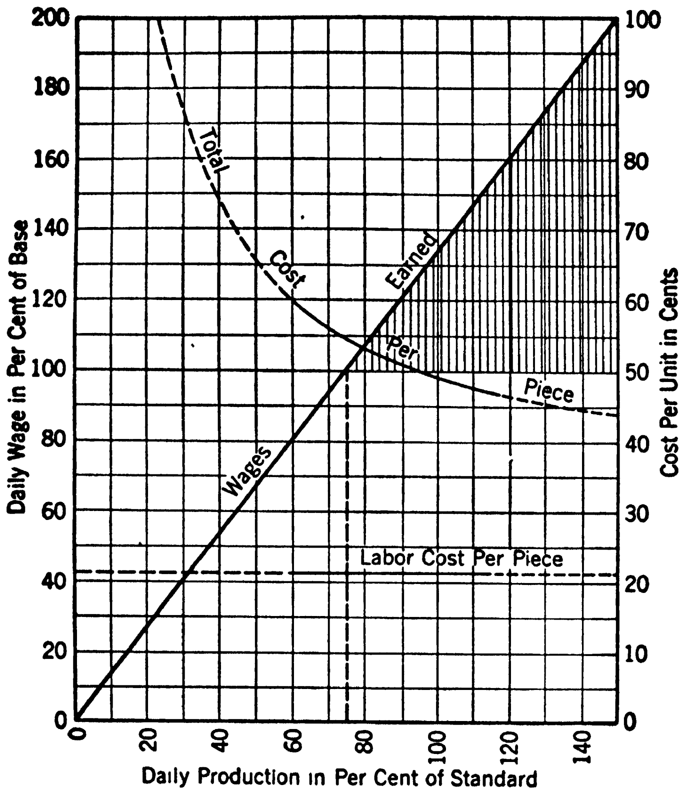


Figure 38. High Straight Piece Rate Plan

TABLE 28. HIGH STRAIGHT PIECE RATE DATA (Without Day Guarantee)

Per Cent of Production H_s/H_a	Per Cent of Total to Base Wage for Full Day $E/H_a R_h$	Total Daily Wage in Dollars E	Number Pieces per Day	Time Saved per 8-Hr. Task in Hours $H_s - H_a$	Labor Cost per Piece in Dollars	Total Cost per Piece in Dollars
0	0	0	0	fictitious	0*	3.84*
10	13	.50	2.4	− 72.0	.21	1.93
20	26	1.01	4.8	− 32.0	.21	1.13
30	39	1.51	7.2	− 18.6	.21	.86
40	53	2.02	9.6	− 12.0	.21	.73
50	66	2.52	12.0	− 8.0	.21	.65
60	79	3.02	14.4	− 5.3	.21	.60
66	87	3.36	16.0	− 4.0	.21	.57
73	96	3.68	17.5	− 3.0	.21	.55
80	105	4.04	19.2	− 2.0	.21	.53
89	117	4.49	21.4	− 1.0	.21	.51
100	131	5.04	24.0	0.	.21	.49
114	150	5.76	27.4	1.0	.21	.47
133	176	6.72	32.0	2.0	.21	.45
145	190	7.31	34.8	2.5	.21	.44

* Not per piece.

task. Such operatives are more likely to try for the immediate benefit than to change all the way to 100% to make it effective.

When a piece rate does cross the day wage line at productions lower than 100% task, it is necessarily more generous in pay than basic piece rate. For instance, if the earning curve crossed the day wage line at 83% task, it would give 20% additional earning at 100% task, and 33% extra at 110% task. This coincides with the usual curve for Gantt and Merrick plans above task and does not have the postponement in reward which those plans have. It also meets the specifications of the English unions which require that a piece rate provide an earning of 133% for good producers, which a basic piece rate fails to do. In general, any piece rate crossing the day wage line to the left of 83% of the high task is considered "high piece rate" in these pages. Because of the combination of lower task and higher slope which such rating brings about, it must be used with caution. The incentive is certainly great, but the assurance of uniform high response is not as certain as in the step plans which use the high rate with safety. No doubt, other plans defined relative to piece rate, such as Bedaux, 75% of labor saving, may sometimes be located on these higher positions of earning, that is, with lower tasks. Piece rate slope, like time rate level, depends largely on what the rates have been and are at the time of installing the new plan. The task may thus be indirectly designated.

Formula for Earning: **(High Piece Rate without Day Guarantee)**

$$\text{Earning} = \text{Time Wages} + \frac{1}{3}\text{Time Wages} + \frac{4}{3}\text{Wages saved}$$

$$E = H_a R_h + .33\tfrac{1}{3}\, H_a R_h + 1.33\tfrac{1}{3}\, (H_s - H_a)\, R_h$$

$$E = 1.33\tfrac{1}{3}\, H_s R_h$$

Any coefficient from 120 to $133\frac{1}{3}$ permissible.

Or in terms of price per piece,

$$\text{Earning} = \text{Number Pieces} \times \text{High Rate per Piece}$$

$$E = N_p \quad (R_p)_h$$

where $(R_p)_h = 1.33\frac{1}{3}\, R_p$

It should be remembered that this R_h is the rate for basic piece rate and must be kept so in the book for the sake of comparisons. In practice, the formula would be $E = H_s R_h$, where this R_h would be 1.33% of that for the basic piece rate.

Cost per Piece.—This plan, although strong, is less strong than some of the step plans. Its total cost per piece is decidedly high with-

out providing for equal security of high average response. It should, therefore, be used with supporting measures. It is generous above most plans, but it is a constant temptation to rate cutting. Like its prototype, unstandardized piece rate, it is likely to be too good to be true. With supporting measures and high class employees, there are few plans more satisfactory.

FORMULA FOR EARNING: **(High Piece Rate with Day Guarantee)**

Below 75% high task
Earning = Time Wages
$E = H_a R_h$
From 75% high task and above,
$E = 1.33\frac{1}{3} H_s R_h$ as above

Cost per Piece.—Above 75% of task, the costs of the high piece rate plan are identical with the foregoing and below 75% of task they are identical with those of ordinary time rates.

Piece Rates in England.—As early as 1876, the cotton spinning industry of Oldham, England, used a task below which a piece rate was paid and above which a series of constant sharings were given in addition. For instance, when the task was three draws in 50 seconds, every three draws which took 50 seconds or more was allowed a piece rate. When three draws took 49 seconds, the pay was piece rate plus one-half the wage saving due to the one second saved. When three draws took 48 seconds, another half sharing was paid, etc. The calculations were made in standard hours rather than in the number of pieces. Although it was called a speed list, the plan was distinctly successful and is credited with good relations as well as with prosperity. This shows an early advance in England which we in the United States have not been wont to recognize. Either Taylor or Halsey might have taken some inspiration from this precedent, the former developing the differential principle into a bonus, the latter simplifying the sharing principle.

Unfortunately, the practice of cutting rates became general in England before the more dependable task was made possible by time study technique. Labor became bitter against the whole movement called "payment by results." Even so, piece rates "obtain in those branches of industry in which England retains her superiority, whereas time-work is more common in those wherein she has been caught up and surpassed."[5]

[5] Arthur Shadwell, *Industrial Efficiency*, 1902.

Commission.—This term is synonymous with straight piece work. It is applied to sales or to any of the enterprises usually carried on outside of the factory. Due to greater independence of this class of employees, commission usually extends into higher figures than piece rate and has consequently earned a more favored prestige. Where sales people in stores work for straight commissions, arrangements are usually made for weekly drawing accounts which represent about 80% of their earnings. The balance, paid in commissions, is sometimes paid only once a month, although many stores pay the commissions weekly. The plan has some weaknesses for sales work. The emphasis on volume may lead to overselling, to superficial explanations, to corner cutting or neglecting of minor lines, and may even lead to price cutting. No doubt, it tends to bring about unwise promises regarding special orders and thereby works against the very important work of simplification. These dangers are more difficult for a sales manager than for a factory manager, for the former is not in as close control as the latter.

Salary and Commission or Premium.—Commission with salary guarantee is identical in principle to piece rate with day guarantee. In either case a rate must be carefully set, but a task per unit of time need not be. The amount of commission on sales above the quota or task is called premium. But these terms are also used in a sense that is not truly piece rate, viz., parallel to a low piece rate and given on top of a salary. In this case the salary serves not merely as a protective time guarantee, but as the majority of the earning. For instance, many large retail stores pay a weekly salary to sales clerks and, in addition, give a small commission of from 1% to 1½% of the value of sales. It may represent from 10% to 20% over salary. The per cent amount of commission, of course, will vary with the value of goods handled by the department. It is usually paid weekly in a separate envelope.

It is considered by some that this plan allows more emphasis upon such factors as: length of service, courtesy, suggestions, cooperation, promptness, attendance, and versatility, rather than on sales alone. Others hold that these qualities may best be stimulated by training or leadership and that there is no more potent incentive for sales work than straight commission or differential commissions. The expression "salary, expense, and commission" is sometimes used to designate a plan in which both salary and expense are deducted, that is, when commission exceeds them to a large extent. From this we conclude that the word commission is even more indefinitely used than its prototype, piece rate.

Piece Work Principle Has High Characteristics.[6]—A well-planned piece rate or commission plan has these advantages:

For the Employee:

It is the most ethical of all plans.

It is the second in simplicity of all plans to understand.

It gives him 100% of labor savings relative to task at whatever pace he chooses to work.

It maintains high rate of increase as he increases effort.

It leaves the upper field of earning wide open and so fosters ambition. This does not hold for a group application.

It is consistent with the highest manliness and independence.

It stimulates interest in management and therefore in cooperation. This is intensified by a group application.

For the Employer:

It secures confidence in fair dealing.

It simplifies labor cost and payroll figuring. This is furthered by group application.

It increases and steadies the volume of production.

It reduces the unit overhead and therefore the total unit cost.

It makes scheduling more dependable.

It brings cooperation with management. This is furthered by group application.

It permits the combination of a relatively low rate with a high task or vice versa.

It may easily be operated on a time rate basis, that is, with decimals of an hour or with minutes.

"Individual piece work is the highest type of incentive and we apply it to all classes of work where we find it practical to do so."[7]

Example of Straight Piece Rate Plan.—An eastern valve company noted for good management since 1909 has used, among other plans, straight piece rate in all of its plants, but only one plant is used here for illustration. This plant has 1,300 employees, some working independently and some in groups. The management has secured production increases from 25% to 50% whenever day rates have been replaced with piece rates. It has "not found any shortcomings with the proper use of the straight piece rate plan." As operated by this company, the incentive plan ties in closely with planning and ac-

[6] The disadvantages are tersely given in an article by W. L. Churchill in *Management and Administration,* August, 1923, but we have not seen fit to include many of them, as we believe they do not obtain when piece rates are properly installed and operated.

[7] W. S. Hosford of the Western Electric Co., *Manufacturing Industries,* Vol. XVI, No. 4.

counting. Tasks and rates are established through a careful study of past records plus motion study. Individual production records are used, but no periodic adjustment of rates is made.

Example of the Hundredth of an Hour Calculation.—A large eastern company making surgical dressings formerly had an ordinary piece rate plan with poorly set rates. In 1925 it changed to this time basis of calculation. It started by correcting the tasks and rates but preferred to go beyond this. Among other improvements, an incentive for indirect labor was provided. About 85% of the employees are now on the plan. The management is pleased with the present arrangement and reports that both production and hourly earnings have increased. It thinks the increases are due in no small part to the individual production records which are posted. The extra clerical work is entirely paid for by the improved efficiency of clerical work which is also now on the incentive basis. Typical efficiency is 102% of task. The instruction sheet (Figure 39) illustrates the derivation of the standard time units for the given operation and the use of ratings for each class of performance. The calculation is based on 900 time units per day.

Example of Piece Rate Plan with Day Guarantee.—The use of a very low day rate as a guarantee with piece rate or Manchester plan, is well illustrated by the case of an eastern rubber company, which has used the plan since 1919. The company has 500 employees, of whom 200 men and 100 women are affected by the plan. The management changed from straight piece work, because the nature of the work made it impossible to avoid all delays which were not the employees' fault. It considers the guarantee a penalization and welcomes the check which it puts upon management shortcomings. As expected, there has been a more speedy removal of the cause of interruption and the guarantee now comes into force rarely.

These interruptions have in times past totaled as much as several hours in a single day, and have often been the cause of dissatisfaction on the part of those most directly affected. Most of the work falls into the class commonly termed semiskilled, and it generally requires from two to three weeks' training before a new employee becomes sufficiently proficient to earn more than the rate given him while learning. When an employee passes from the learner's class into the ranks of the piece workers, he is given a day guarantee equal to the product of his learner's rate and the number of hours which he will regularly work in his job. Under present conditions, a first class piece worker will average daily earnings as much as 170% of his guarantee, while an average employee reaches about 140% of his.

Date..

Part Name.....4 Ounce Synol Soap..

Operation......Packing..

Operator.......Julia and Margaret..

Dept...........Soap..W. R. D.

No.	**Element**	**Rating**
1	Fold circulars	100
2	Get forms	80
3	Place bottle with circular in form	120
4	Get cartons	100
5	Date cartons	100
6	Enclose bottle and form in carton and pile	115
7	Fatigue 5%	
8	Material 8′ Daily—(Get dater, etc.)	

1	2	3	4	5	6	7	8
20/50	50/250	19/5	20/48	40/48	6	27′ Daily	8′ Daily
		17/5		38/48	6.5		
		17/5		41/48	9		
		16/5		36/48	6.5		
		17/5		43/48	7		
		23/5			9		
		14/5			7		
		18/5			6		
		19/5			7		
		17/5			6		
	Average	17.7/5		Average	7.0		

Calculation

#1—20/50 @ 100 = .40

#2—50/250 @ 80 = .16

#3—$\sqrt{\frac{17.7 \times 14}{5}}$ @ 120 = 3.75

#4—20/48 @ 100 = .42

#5—43/48 @ 100 = .90

#6—$\sqrt{7 \times 6}$ @ 115 = 7.50

Total Rated Time per carton in seconds = 13.13

9 (hrs.) × 60′ = 540′ per day

35′

505′

505 × 60 = 30,300

$\frac{30,300}{13.13 \times 12}$ = 192 Dozen per day

$\frac{900}{192}$ = 4.7 Standard Units per Dozen

Figure 39. Instruction Sheet for Packing Liquid Soap

Example of the 100% Premium Plan.—It is interesting to find that an eastern company making printing machinery calls its incentive the Halsey plan. This name would be quite correct if that plan generally allowed employees 100% of the premium, rather than 50%. There is no reason requiring us to give detailed differences distinct plan names, but many would entirely misunderstand if we did not. The classing of a piece rate with a Halsey premium does bring out the fact that piece rate is 100% premium or all wages saved relative to task. In this case, it was a development from the Halsey (50-50) sharing plan which had been in operation for ten years. The management felt that to give a premium of less than all the labor saving was bad psychology. Rates were estimated only and lacked real foundation. The change to 100% premium took place eighteen years ago and has resulted in improved morale, fewer complaints, and a fairer distribution of earnings. It is accompanied with individual production records. The efficiency cited as typical is 125%.

The company manufactures a line of stitching and perforating machines used in book binderies. All parts going into the machines are made and finished in one plant and although there are only 100 on the payroll, the work takes in all general purpose metal cutting machines and a considerable variety of bench work, including erecting of the complete machines. The sizes of lots or orders for parts machined are comparatively small, due to maintaining a small inventory. To operate the rate department economically, and for several other reasons consistent with best practice, a system of setting standard time on jobs without the necessity of constantly taking studies is used. The standards, however, are based on accurate time studies. In setting standard times, allowance is made for fatigue, personal and miscellaneous trouble, "stock up," etc. These allowances are also standardized and shown on a chart that is easy to understand.

The number of hours saved per job constitutes the hours earned. The hours saved multiplied by the operator's day rate equals the amount of premium earned in dollars and cents.

Example

Standard operating time per piece	1 hr.
Pieces in lot	10
Total standard operating time	10 hr.
Set-up time	2 hr.
Total standard time or allowed time	12 hr.
Actual time taken to do job	10 hr.
Hours saved	2
Day rate	$ .60
Premium amount earned on job—2 × $.60	$1.20

Operators are penalized for defective workmanship where it is proved beyond doubt that they are responsible. The amount of penalty depends on the value of the part up to and including the last operation completed. The penalty is deducted from the premium earnings only. Assuming that an operator who makes $1.20 premium, spoils a piece valued at $.75 up to a certain operation, he would be penalized $.75 which would be deducted from the $1.20, thus giving him only $.45. If the amount of penalty exceeds premium earnings on a particular job, the operator will not be penalized beyond his premium earnings. Both the setting up of a job and the operating time are on an incentive basis. A set-up man is used only to assist all operators and to bring all the necessary tools on each job, beforehand.

The production time ticket (Figure 40) is used in scheduling and is made out for every operation performed on a part. The dupli-

PRODUCTION TIME TICKET	SHOP ORD. NO. 45887	OPER. NO. 2

DATE ISSUED 3/23	DATE TO BE COMPL. 3/24	DEPT. NO. 1	MACH. NO. E 10	MAN'S NO. 55

QUANTITY WANTED 50	PART NO. 2787-A	NAME OF PIECE Die Clamp Nut

STOCK DELV'D 3/22	TOOLS DELV'D Yes	STOCK MOVED —	NEXT OPER. MACH. NO. 3

STANDARD TIME .20	STD. SET UP TIME .16	TOTAL STD TIME 10.16

ROT NO.	INSTRUCTIONS	TOOLS REQD.
2	3/32" × 6" H. S. Saw	
	Gauge 314 - Bin 241	
	Ga. Limits .005	

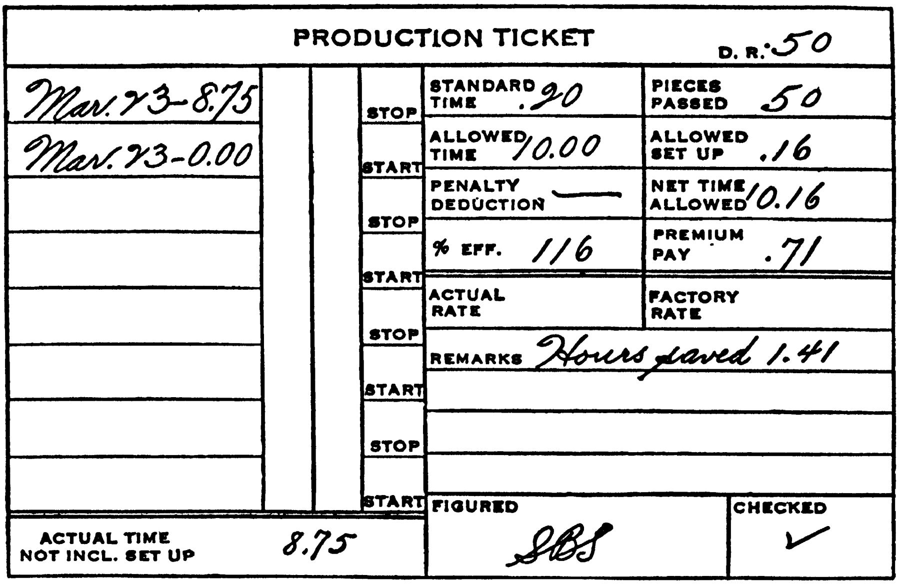
NO. PIECES REC'D BY WORKER	DATE FINISHED	REJECTED FOR REPAIRS	REJECTED FOR SCRAP	GOOD	INSPECTOR
50				50	SBS

Figure 40. Production Time Ticket for Machine Operation

cate remains in the timekeeper's file, and the original is given to the employee performing the operation for his information, and is also used as a receipt for tools taken out of the tool room. The names of the tools used are recorded on the original and duplicate. At the completion of the job in the shop, this ticket is sent to the cost department where it is used in ascertaining the actual cost of each job. Figure 41 is the reverse side of Figure 40 and is self-explanatory.

Example of Standard Hour Plan.—A well-known company making paper products uses a method of calculating wages which is

in reality the standard hour form of piece rate with day guarantee. Two rates are used.[8] One is a "guarantee rate" set so that the less skilled may earn the going wage of the locality. This rate may vary



PRODUCTION TICKET D. R. 50

Mar. 23-8.75			STOP	STANDARD TIME .20	PIECES PASSED 50
Mar. 23-0.00			START	ALLOWED TIME 10.00	ALLOWED SET UP .16
			STOP	PENALTY DEDUCTION —	NET TIME ALLOWED 10.16
			START	% EFF. 116	PREMIUM PAY .71
			STOP	ACTUAL RATE	FACTORY RATE
			START	REMARKS Hours saved 1.41	
			STOP		
			START	FIGURED SBS	CHECKED ✓
ACTUAL TIME NOT INCL. SET UP 8.75					

Figure 41. Production Ticket for Machine Operation (reverse side)

from one-third to one-half more than the starting rate. Another rate called the "standard time rate" is established by job standardization and is the same for all operators.

$$\text{Let the guarantee rate} = (R_h)_1 = \$.10$$
$$\text{Let the standard time rate} = (R_h)_2 = \$.20$$

In all cases these two rates are figured separately and the amounts added to derive the total wage.

$H_s \div H_a$	Production	Standard Time	Actual Time	$H_s\ (R_h)_1 + H_a\ (R_h)_2 = E$
100%	15 pieces	15 hr.	15 hr.	15 × .10 + 15 × .20 = \$4.50
75%	15 pieces	15 hr.	20 hr.	15 × .10 + 20 × .20 = 5.50
133%	15 pieces	15 hr.	10 hr.	15 × .10 + 10 × .20 = 3.50

Prorating actual time to the same 8-hour day, the three results would be as follows: \$2.40, \$2.20, \$2.80. At 100% task and above, this amounts to a piece rate the standard hour rate of which is the sum of the two rates, or \$.30. This is covered by the regular formula $E = H_s R_h$, but below 100% task the separation of the rates necessitates the special formula shown above. This procedure is recom-

[8] Bulletin of Taylor Society, Vol. 5, No. 4.

mended "where the work is constantly changing and many small jobs are done." Compensation for versatility and other intangibles may be made by putting more into the guarantee rate. Only part of the incentive is concerned with volume and this part may be constant for all. The plan has been erroneously called a standard time plan.

Piece Rate for Part of Production.—What may be confused with piece rate plans, but mathematically is very different, is the plan used by an eastern textile company in one of its departments. The case is unusual and needs full explanation. It is like the salary and commission plan, where commission is not paid on a first minimum. The machines used are very sensitive to the variations in the grades of yarn run, and the production is influenced by any dropping of the yarns below a given standard. The reason for such loss of production is not so much because the machines must be operated at slower speeds, but rather to the increase in the number of knitting imperfections which arise and which require the machine to be stopped while the operator mends such places so that they may not appear as damages in the finished cloth. Not only is production lost, but the demands upon the operator are increased where bad running of this type is encountered.

Under a former practice of paying straight piece rates, the operators contended that the running qualities of the yarns furnished them was a matter beyond their control—a condition for which they should not be penalized in the reduction of their ability to earn a standard rate. Also, that when their production was low due to such conditions, they were working harder and receiving less pay. This resulted in the necessity of frequent adjustments of pay at the end of each period and such adjustments were lacking in uniformity. In order to standardize the treatment of such cases, the present plan of payment was evolved and has been in satisfactory use for twenty years without any fundamental changes. It has eliminated any question of pay adjustments and serves to distribute the burden of poor running work on a fairly equitable basis between the company and the employee.

Method of Calculation.—The method of working out the rates is comparatively simple. If the standard weekly output of each job were 750 lbs., the standard weekly rate for an average operator might be $40 for a week. A guarantee of one-half the average weekly rate, or $20, is given the operator, which covers compensation for all production up to 250 lbs. All production over 250 lbs. is paid for at the rate of 4 cents per lb. The method is to take one-third

the estimated weekly production and cover this with one-half the average weekly earning. The remaining two-thirds of the estimated weekly production is figured into one-half of the average weekly earning to establish the rate per pound paid for all production over the minimum amount required under the guarantee. Should the operator turn off less than 250 lbs. in a full week's work on this particular job, the guarantee of $20 would still be paid, but any such fall down in production is unlikely except by fault of the operator.

Instead of paying for all units on a piece rate when the employee exceeds task,[9] the company only pays for the units exceeding task. The formulas for earning cannot, therefore, be at all like the Taylor formula. The particular arrangement of low task and rates makes the formula identical with that of the (50-50) Halsey formula:

$$E = H_a R_h + (H_s - H_a)\frac{R_h}{2}$$

(a) The first 250 units are paid by a flat guarantee of $20, which if figured per unit would be at the rate of $.08.

(b) Additional units are paid $.04 a piece. 500 units @ $.04 = $20.

(c) The $20 guarantee as in (a) and the additional piece earning $20 as in (b) are added, giving the employee $40 for 750 units, which in terms of piece rate amounts to $.05⅓.

Claims for Plan.—The plan does not require excessive calculation and certainly puts the emphasis on the additional amounts. The double price per unit below task is not unusual under any day guarantee plan.

In addition to the above, the operators are grouped into A and B classes, in accordance with the quality of the work which they are turning out over a period of time. A class B knitter receives the standard rate of compensation as worked out above, while a class A knitter is paid a quality bonus of 20% above this rate. Rates for other classes of work are easily determined by simply changing the factor of estimated poundage production and using the same method of calculation explained above.

One $30 a week clerk takes care of the 30 employees. Their efficiency ranges from 75% to 125% and their wages from $35 to $60 per week. It is not considered that this method is the ideal one, nor does it perhaps wholly compensate for some irregularities in the performance, but it has met the situation in this particular department with undoubted success. The task was intermediate in degree.

[9] See also Figure 42.

Example of High Piece Rate Plan.—A large eastern gas engine company presents a critical analysis of its former incentive practice together with a description of its present practice. One thousand men and a few women out of a total payroll of 2,135 employees are affected. Of these, 148 are in offices and 975 are on an hourly basis. Rigid inspection controls quality. Comparing results before and after the installation of correct standards the management observes that "the shortcomings came from the method of application rather than from fallacies in the plan itself."

1. Formerly the setting of piece rates seemed of minor importance as compared to other duties of the foreman, so that rates were established in a very haphazard fashion, in many instances by asking an operator how many he could produce.
2. Partiality was shown at times.
3. Rates many times were not adjusted in accordance with change of tools, method and engineering design.
4. As no time study record was made, in case of dispute there was no means of showing how standard performance was accomplished.
5. Rates were reduced or increased at random.
6. No definite schedule of base rates with ratio of incentive to hourly hiring rates existed.
7. Little coordination was possible between manufacturing and inspection, engineering, tool design, and accounting.
8. No standard or check of the ratio of day work hours, both direct and indirect, to piece rate hours was available.

Claims for Improved Plan.—"The straight piece rate plan is more satisfactory than other plans for the reasons that it requires less clerical help in the accounting department to keep it operative, and that it abolishes the feeling among the direct labor personnel that they are being paid under a plan which to them is not fully understandable and under which they are not certain but that they may be cheated on pay day.

"The amount of clerical work is no more than would be required were there any other incentive plan in operation, and but one more than would be required were there no incentive plan in operation. This clerk is also responsible for the typing, duplicating, distributing and posting of routings.

"Time standards are based on average performance during the study and base rates are comparatively high. On this basis any average operator is able to earn a good day's pay, while an exceptionally speedy, competent man by exceeding the base up to 20% is com-

pensated for his ability by an attractive day's pay, thus high class men are attracted and held. They produce a quality product at an economic unit cost.

"After a permanent rate has been set adjustments either upward or downward, except when the method is changed, are carefully made. Consequently minimum dissatisfaction and minimum labor turnover has been experienced.

"The best operators produce up to 20% less than standard time. By producing in up to 20% less than standard time, our best operators consequently earn up to 20% over base rate. Elapsed time cards are in such shape that any individual record can be made if desired by use of the Hollerith Tabulating system. It has always been the policy of this company to make promotions within the organization when possible."

The Maxi-Pay Premium Plan.—A plan which is mathematically identical with high piece rate is used by a New England machine tool company. Day wages are guaranteed up to 75% of high task, and a 1% premium is given for every additional point of efficiency above 75%. The particularly good feature of this installation is that the time rates are constantly increased by a prearranged classification.

Class AA includes subforemen and leaders in charge of groups of mechanics. From this class, foremen and shop executives are promoted as far as possible.

Class A includes skilled mechanics of demonstrated first class ability.

Class B includes mechanics of good average ability.

Class C includes mechanics of limited experience.

Class D includes apprentices, both special and regular. They go automatically to one of the higher classes at the completion of their apprenticeship.

Class E includes all kinds of labor and a few skilled men, not directly productive.

Promotion to a higher class requires an average efficiency of 90% over a period of three months.

High Piece Rate Plan in Railroading.—One of our smaller but well-managed railroad companies has used straight piece rates in its car department for thirty-six years and in its locomotive department for eighteen years. There are 1,256 men on this plan. Time studies are used and individual production records are kept. For operating the plan, 58 inspectors and 10 clerks are necessary. Individual efficiencies reach as high as 40% above task and wages 30% above day

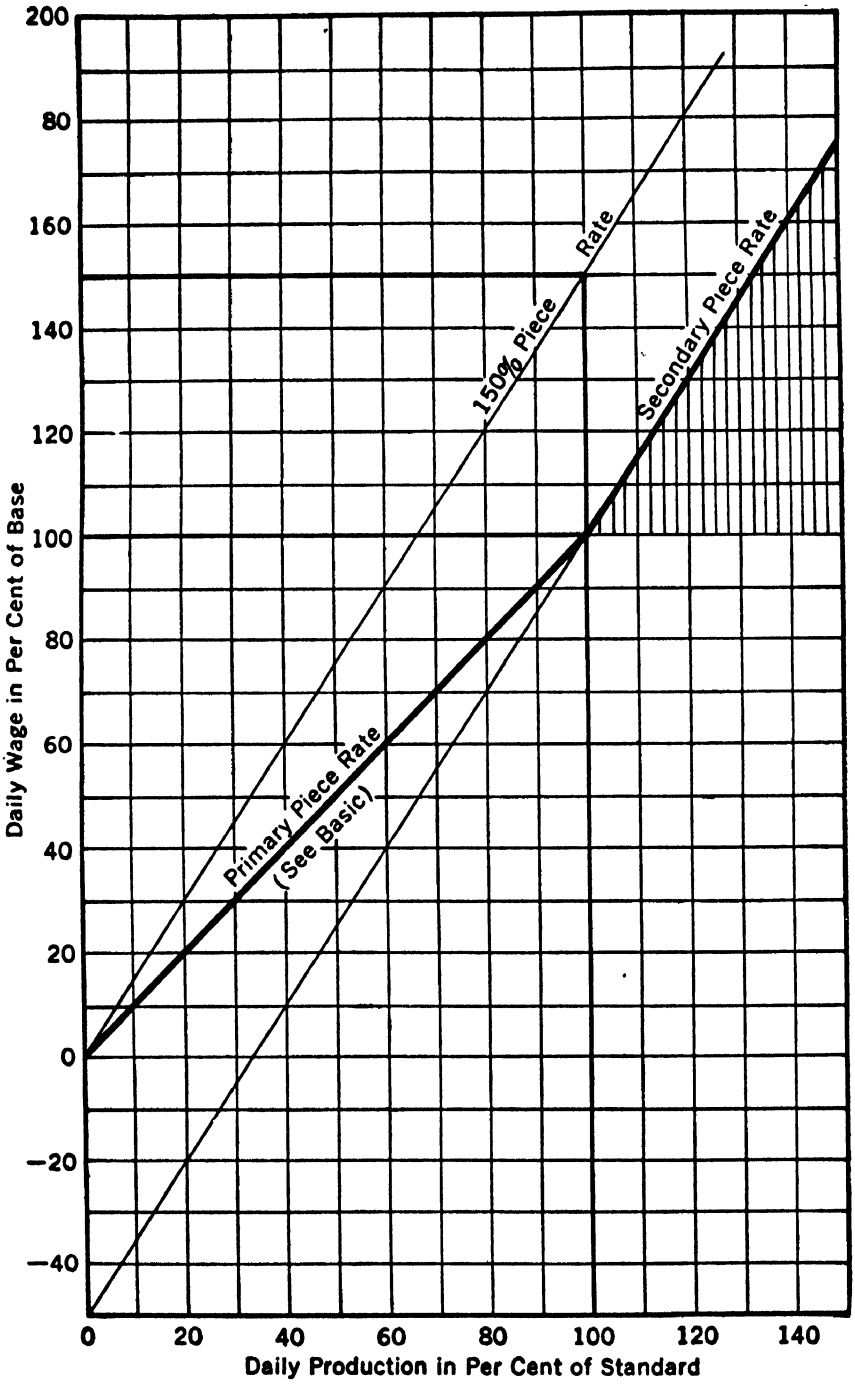


Figure 42. Multiple Piece Rate Plan—Two Rates

earning. The management claims for the plan, increased output, decreased number of employees, better earnings per employee, decreased labor turnover and satisfied employees.

Multiple Piece Rate Plan, Two Rates.—An eastern company manufacturing agricultural implements started out with a regular Taylor Differential Piece Rate plan, found difficulties with the lower rate, and so decided to eliminate that and the consequent step bonus. Thus they developed a two-rate plan as follows: Basic piece rate is paid up to the 100, 100 point. From there a straight earning curve is drawn parallel to the 150% piece rate line which, as may be seen in Figure 42, makes a negative intercept on the earning axis. This is a very steep slope, much like the one used as a constant total cost criterion in Chapter 3. By this means earnings are less than the Taylor and Gantt plans just before high task but higher than either eventually. The plan provides a real incentive to the skilled type of employee, and should not be as discouraging to the less skilled as the differential plans. For instance at a particular task:

For 240 pieces per hour or less, the price is 22¢ per 100.
For all over 240 pieces per hour, the price is 33¢ per 100.

This would amount to a 109% rate for all units, assuming that the employees were working at 120% of task. There are few cases of failure to make the task. Average production is around 140%. The formula for earning above task is:

Premium Hours = Production Hours − Actual Hours
Earnings = Actual Hours × Hour Rate + Premium Hours × 1.50 Hour Rate

$$E = H_a \quad R_h \quad + (H_s - H_a) \quad 1.5\, R_h$$

or

$$E = 1.5\, H_s\, R_h - .5\, H_a\, R_h$$

This steep slope curve must have a high task, and the steeper this slope the greater is the need for accuracy in task-setting.

Details of Operation.—The actual earnings are not figured on each job, but the actual hours and production hours are totaled for the week. The difference between the two gives the premium hours. One-half of the time card is retained by the payroll department and the other half goes to the cost department. For the sake of standard costs, all operations or jobs are classified by letter which signifies the standard hour rate for the operation. During the morning, each operator receives a slip giving his production for the previous day. This enables him to keep a check on his earnings for each day. These slips are made out in duplicate and the carbon copy goes to the planning department to credit the work against the order.

Claims for Plan.—The advantages of this system are:

(a) After the task or standard production rate has once been properly set, it remains the same regardless of changes in labor conditions. The hour rates of operators may be adjusted to suit labor conditions.

(b) Individual hour rates may be set to reward the individual according to his real worth to the organization. Not only his skill and speed, but also his care of equipment, punctuality, regularity of attendance, loyalty, etc., are considered.

(c) An operator may be gradually worked into more difficult jobs, but his hour rate does not have to be changed until he becomes fairly skilled in the more advanced work.

Efficiencies have gone as high as 150% of task and wages as high as 175% of base.

CHAPTER 8

PIECE RATE PLANS WITH STEP BONUSES

First class men are not only willing but glad to work at their maximum speed, provided they are paid from thirty to one hundred per cent more than the average of their trade.—F. W. Taylor.

Taylor's Belief in High Wages.—Long before Henry Ford preached his doctrine of high wages and more markets, F. W. Taylor reminded employers that low wages did not constitute low costs. As one who had been a machinist and a foreman, he knew that individual production varied enormously and that high class American workmen would prefer to work harder, provided they could earn superior wages. Although he did more than any other man to establish the economy of extra-financial incentives, yet he did not place the main emphasis on incentives. What he did emphasize was the improvement of tools and methods for each job, the establishment of a high but fair task, the centralization of control, the selection and training of the man for the task, and finally, the reward of a generous incentive.[1]

The Taylor Differential Idea.—This is all very modern, but Taylor developed it back in the '80's. In the first place, he was able to gather the very best men of each trade. This was possible because no other employers were offering such high wages. With this in mind, it is understandable that he should have conceived not only a generous reward but also a severe punishment for those who would not produce up to task. Instead of starting at basic piece rate and building his reward on top of that, he deliberately instituted a lower piece rate on which he could afford to put the extraordinary incentive of a 50% increase at task (Figure 43). "The lower differential

[1] "Mr. Taylor used time studies for fourteen years before he called it to the attention of manufacturers. In June, 1895, he presented before a Detroit meeting of the American Society of Mechanical Engineers a paper on time study and rate-setting entitled 'A Piece Rate System.' His audience was not at all prepared for his ideas and methods, and in consequence the discussion following the reading of this paper centered entirely around the differential piece-rate system, which he was also developing, rather than around his methods of determining the time allowance for work by means of time studies. He tried to lead the discussion toward time study, but with little success. In 1903, Mr. Taylor again presented a paper before the A. S. M. E. entitled 'Shop Management,' which afterwards came out in book form. This book contained numerous references to time study and was virtually an appeal to manufacturers to give time study the attention that it merited. Since then the idea has spread rapidly." Dwight V. Merrick, Taylor Society Bulletin, Vol. VIII, No. 2.

rate should be fixed at a figure which will allow the workman to earn scarcely an ordinary day's pay when he falls off from his maximum pace, so as to give him every inducement to work hard and well." This he called, in 1884, "a differential rate system of piece work" and later the differential piece rate plan. It indicated exactly where the task was and offered the highest monetary incentive to make the task, which had ever been proposed. If an employee made 99% of the task one day and task, or say, 101% of task next day, his wages for the two days would be over 50% different. Naturally, the plan eliminated all those who could not make the task day after day without injuring their health.

The Incentive Did Not Stand Alone.—It should also be noted that the "Taylor System" did a great deal to assist the employees in making the tasks. A scheme of functional foremanship was devised which provided specialized foremen for tools, speeds, etc. This was accompanied with a centralized production control. By these means delays were eliminated and employees could keep at work constantly. It is true that Taylor did a good deal of "fighting with the employees," but he also instituted rest periods and brought about other advances in management which have contributed immeasurably to the well-being of all employees today.[2]

Modifications.—Taylor's associates, Gantt and Merrick, modified his plan as will be shown later, each in his own way in order to do away with the punitive part of the differential. Both modifications were first intended for temporary use leading to the Taylor plan. The Gantt modification proved so successful that Taylor came to use it entirely. Had Taylor lived, he would probably have endorsed the other changes toward mutual trust which have become general, particularly since employees have themselves come out for the elimination of waste.[3] Thus the Taylor differential bonus has been largely displaced by the Gantt or Merrick plan, but it is still used, in a milder form, that is, with the substitution of the basic piece rate for the punitive low piece rate up to task. The amount of bonus may be less than 50% day wages as the 50% was built up on a lower rate. In this form the plan is perfectly workable and can be little improved where the following rules prevail:

1. Have all jobs improved and standardized at a high, but fair task.

[2] Dr. L. P. Alford recently pointed out that "the whole impact of Taylor's work was directed at employer-employee relations."

[3] Wm. Green, president of the American Federation of Labor, has pledged the cooperation of union labor in every attempt to reduce waste, but declares that the resulting benefits should show proportionately in higher wages as well as in increased profits.

2. Have all jigs and tools properly provided when the job is scheduled.
3. Have a production control system which obviates all delays.
4. Have a rigid system of inspection.

Of course, the plan may still cause discontent where an employee has been used to time wages or to a time guarantee with piece rate, but where he has been used to a straight piece rate, he can have no objection, that is, if basic piece rate is used for the low rate. In one company where these conditions are met, a 20% bonus is found to be adequate.

FORMULA FOR EARNING:

$$\text{Earning up to task} = \text{Number of Pieces} \times \text{Low Piece Rate}$$
$$E = N_p \quad (R_p)_1$$

$$\text{Earning above task} = \text{Number of Pieces} \times \text{High Piece Rate}$$
$$E = N_p \quad (R_p)_2$$

$$\text{Where } (R_p)_2 = 1.50 \quad (R_p)_1 \text{ usually.}$$

or $$E = 1.25\, H_s\, R_h$$

Key to Symbols

E = Earning in dollars (the vertical variable)
H_s = Hours standard (the horizontal variable)
H_a = Hours actual (a constant)
R_h = Rate per hour in dollars (a constant)
R_p = Rate per piece in dollars
N_p = Number of pieces

Cost per Piece.—The direct labor cost curve of the Taylor plan consists of two horizontal lines for the piece rates, with a step between them (Figure 43). The total cost per piece curve similarly gives a gradual slope characteristic of piece rates. In this curve the step should be ignored as already explained under the differential time plan, for we must always consider the group as a whole in the matter of total costs. That is, the cost due to those working above task will be merged with the cost of those working below. Again, as in all piece rates, the total cost curve is low for high production and it is exactly in this latter location that this plan succeeds best. The cost here is below the average for the plans. It should be noted also that the slope of this total cost curve approaches the horizontal for high production. This is due to the large amount of the reward. As a result of this approach to the horizontal, there is less variation to be expected in total cost under this and other high incentive plans than in the lower incentive plans.

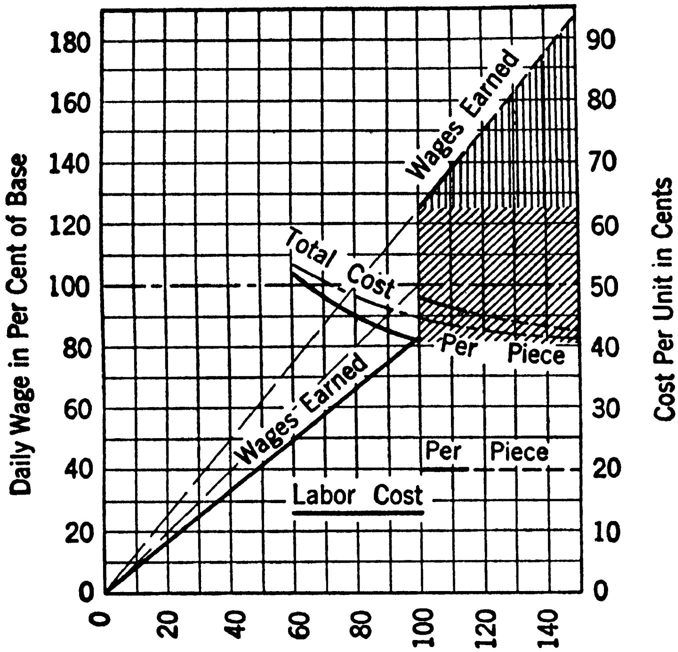


Figure 43. Taylor Differential Piece Rate Plan

TABLE 29. TAYLOR DIFFERENTIAL PIECE RATE DATA

Per Cent of Production H_s/H_a	Per Cent of Total to Base Wage for Full Day $E/H_a R_h$	Total Daily Wage in Dollars E	Number Pieces per Day	Time Saved per 8-Hr. Task in Hours $H_s - H_a$	Labor Cost per Piece in Dollars	Total Cost per Piece in Dollars
60	50.0	1.92	14.4	− 5.3	.13	.52
66	55.5	2.13	16.0	− 4.0	.13	.49
73	60.7	2.33	17.5	− 3.0	.13	.47
80	66.6	2.56	19.2	− 2.0	.13	.45
89	74.3	2.85	21.4	− 1.0	.13	.43
100	125.0	4.80	24.0	0.	.20	.48
114	143.0	5.48	27.4	1.0	.20	.46
133	166.6	6.40	32.0	2.0	.20	.44
145	181.0	6.96	34.8	2.5	.20	.43

Much has been said about the convenience of having the piece rate constant for direct labor cost, but it is rarely pointed out that a constant curve for the total cost per piece is really the condition which allows dependable estimation of costs for pricing. The high labor cost has such effect on production that the whole operation is steadied and is under the best control.

Example of Taylor Differential Piece Rate Plan.—An eastern company making mechanical counters is one of the few adhering to the original Taylor plan without any modification. Out of 150 employees, 95 men and 33 women are included in the plan which has been in use for eighteen years. This does not include employees on maintenance or indirect production. Four clerks are required to operate the plan in the factory and two in the office. Careful job standards are established and individual production records are kept. The typical efficiency is 115% of task and wages 25% to 30% above day rates. The management claims that the employees are satisfied. We may add that they have very high-grade mechanics and that the plan is especially suitable for that type of employee.

Merrick Differential Piece Rate.—Taylor foresaw the need for more than two rates. "In cases where large and expensive machines are used such as paper machines, steam hammers, or rolling mills, in which a large output is dependent upon the severe manual labor as well as the skill of the workmen (while the chief cost of production lies in the expense of running the machine rather than in the wages paid), it has been found of great advantage to establish two or three differential rates, offering a higher and higher price per piece or per ton as the maximum possible output is approached."

We have shown that the low rate of the Taylor plan below task was severe and greatly disliked by employees. D. V. Merrick, in meeting an emergency problem at the Winchester Repeating Arms Co., attempted to correct this by starting with basic piece rate. This not only obviated the objection, but made it easy to install his plan where straight basic piece rate was already in operation. Furthermore, he realized that employees were by no means to be divided into two classes: those who could do the higher task day in and day out, and those who could not. He felt that, for the sake of development, the many employees who were either new or still struggling for better production should be encouraged.

With this in mind, it was natural to break up the one large step into two smaller steps, putting one of them at task and the other at some point a little below task where it would be more in reach of the developing employee (Figure 44). He placed this first step at about

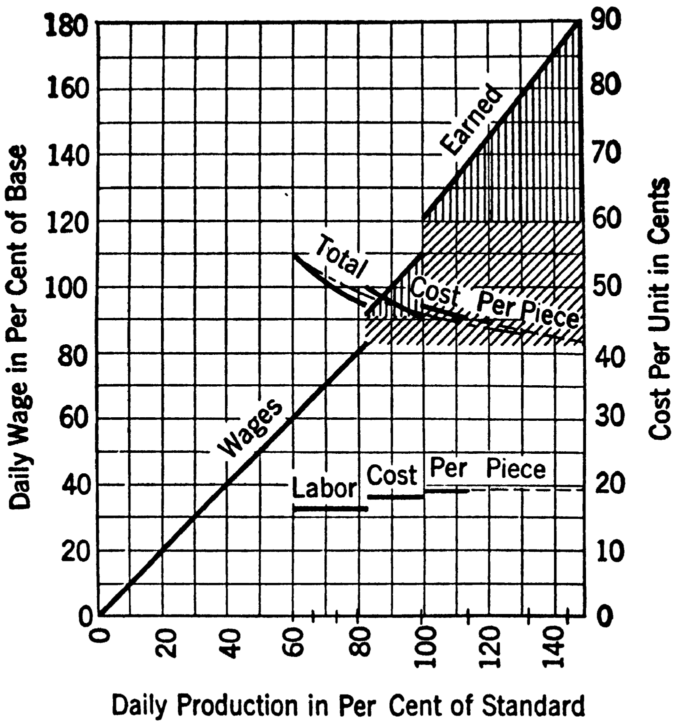


Figure 44. Merrick Differential Piece Rate Plan

TABLE 30. MERRICK DIFFERENTIAL PIECE RATE DATA

Per Cent of Production H_s/H_a	Per Cent of Total to Base Wage for Full Day $E/H_a R_h$	Total Daily Wage in Dollars E	Number Pieces per Day	Time Saved per 8-Hr. Task in Hours $H_s - H_a$	Labor Cost per Piece in Dollars	Total Cost per Piece in Dollars
60	60	2.30	14.4	− 5.3	.16	.55
66	66	2.56	16.0	− 4.0	.16	.52
73	73	2.80	17.5	− 3.0	.16	.50
80	80	3.07	19.2	− 2.0	.16	.48
89	98	3.76	21.4	− 1.0	.18	.48
100	120	4.61	24.0	0.	.19	.47
114	137	5.26	27.4	1.0	.19	.45
133	160	6.14	32.0	2.0	.19	.43
145	174	6.67	34.8	2.5	.19	.42

83% of high task. He took as the whole amount of bonus 20% and divided this equally, 10% bonus at 83% of task and 10% at task. This resulted in three piece rates, all, of course, pointing to the origin. The intermediate piece rate cuts the corner usually turned at (100, 100). This is a much simpler way of giving high wage to this stage of production than by the curve obtained under the Emerson efficiency bonus plan and the others of the empiric group.

Extra Step Needed for Development.—While this plan loses some of the strength of the one large step, it is just the thing needed to encourage developing employees. At the same time, it is generous to fully developed employees. There is no reason why other amounts or production points may not be used if conditions warrant. In fact, we applied this plan about 1920 in an improved form, by dividing the whole bonus into two uneven steps such as 8% and 12%, the smaller one located at 83% production and the higher one at task. The importance of this is perhaps psychological only, but the repetition of the same bonus for a much harder achievement may not seem as equitable to the employee as a higher bonus for this more difficult achievement. It is no more difficult to figure the rates this way than to figure them in equal amounts. In either case, all amounts of payment are tabulated. In the installation just mentioned, one payroll clerk took complete care of 250 employees on this plan about as easily as she had previously done on straight basic piece rate.

In conclusion, it might be pointed out that any slope less than piece rate is scarcely worth the trouble of figuring for the sake of incentive on high productions. Plans with less slope than this depend either upon steps or low task for their incentive. When we have the combination of the high slope of piece rate and the steps also, we have very generous incentives. Under the differential piece rate plans, employees are as likely to make a strong effort to win the bonuses as under the differential time plans, but they are much more likely to continue increasing production under the former.

FORMULA FOR EARNING:

Earning up to 83% task = Number of Pieces × Basic Piece Rate

$$E = N_p \quad (R_p)_1$$

$$\text{or } E = 1.00\, H_s\, R_h$$

Earning from 83% to 100% task = Number of Pieces × Intermediate Piece Rate

$$E = N_p \quad (R_p)_2$$

$$\text{or } E = 1.10\, H_s\, R_h$$

Earning at and above

$$\text{task} = \text{Number of Pieces} \times \text{High Piece Rate}$$
$$E = N_p \quad (R_p)_3$$
$$\text{or } E = 1.20\, H_s\, R_h$$

Where $(R_p)_2 = 110\, R_1$ or Where $(R_p)_2 = 108\, (R_p)_1$

$(R_p)_3 = 120\, R_1$ $(R_p)_3 = 120\, (R_p)_1$

An $(R_p)_4 = 133\frac{1}{3}\ (R_p)_1$ might be used from 110% task and on up. (See high piece rate plan, Figure 38.)

Cost per Piece.—The direct labor cost of the Merrick plan is on three constant levels. The total cost per piece is an even curve disregarding steps as in the Taylor plan and approaching a horizontal condition under higher production. All that has been said under the Taylor plan applies here.

Example of Merrick Plan.—We have failed to find a recent factory case for this plan. As the plan is a particularly good one, this is surprising. The explanation seems to be that its namesake has not advertised it; in fact, he claims it is little more than a special adaptation of the Taylor idea, "to meet an emergency." W. C. Dickerman describes it[4] without giving it any name other than a "step-up bonus." Possibly it is being used elsewhere under the name of Taylor differential bonus plan. The Merrick principles have certainly been sufficiently tried out and found effective as well as extraordinarily simple. In England it has been used with a day guarantee, but the extra step at lower production makes that unnecessary. We hope it may be used more in the future, especially where straight basic piece rate has been in existence. The plan is particularly adaptable to sales work.

[4] Incentives for Individual Production, Thirteenth Annual Meeting, Chamber of Commerce of the United States. Virtually the same plan was used for weavers in France in the early '80's by Paul Leroy-Beaulieu. See his Essai sur le Partition des Richesses and Emile Chevallier's Les Salaries au XIX me Siecle.

CHAPTER 9

COMBINED TIME, BONUS, AND PIECE RATE PLANS

> Men, as a whole prefer to sell their time rather than their labor and to perform in that time the amount of labor they consider proper for the pay received.—H. L. GANTT.

Gantt Task and Bonus Plan.—The Gantt task and bonus plan, like the Manchester plan, is a cross between the time plan and the piece rate plan. It is decidedly different, however, in its effectiveness because the transition from the former to the latter is by means of a high step bonus at task. (Figure 45). This not only gives a high earning location for the curve, above task, but it gives the sharp sloping curve pointing to the origin as provided by the Merrick plan. The "task and bonus plan" was developed in 1901 while Gantt was working with Taylor at the Bethlehem Steel Works, and was intended as a means of upgrading men to the skill required to work under the Taylor differential piece rate plan, and to be used optionally and temporarily during the installation of the Taylor methods. He also tried a bonus of \$.50 a day but dropped that.

Gantt was Taylor's associate and an able leader in the field of scientific management. He carried out the principles laid down by Taylor in almost every respect, but far excelled him in his relations with employees. He not only put the emphasis on having the materials in the right place at the right time and in the right condition, but he felt that the employee should never be allowed to suffer in wages when these conditions of management were imperfectly realized. He believed that the incentive would be nearly as strong if he retained the Taylor plan above task, but replaced the punitive piece rate below task with a low time guarantee. There is nothing radical in having this day guarantee somewhat below average wages, the danger is in having it too high.

According to H. K. Hathaway, Mr. Gantt first experimented with the following formula at and above (100, 135).

$$\text{Earning} = \begin{matrix}35\%\ \text{Hours}\\ \text{Actual}\end{matrix} \times \begin{matrix}\text{Rate per}\\ \text{Hour}\end{matrix} + \begin{matrix}\text{Hours}\\ \text{Standard}\end{matrix} \times \begin{matrix}\text{Rate per}\\ \text{Hour}\end{matrix}$$

$$E = .35\ H_a\ R_h + H_s\ R_h$$

$$E = (.35\ H_a + H_s)\ R_h$$

The earning curve above task for this formula is paralled to basic piece rate, but of less slope than the high piece rate curve from its starting point. The earning curve for the present plan has the full piece rate slope pointing to the origin from point (100, 120). The earning is figured in terms of standard hours accomplished.

Amount of the Steps Varies.—While it is usual to define this plan as having a bonus of 20%, Gantt actually varied this percentage depending upon the nature of the work from 20% to as high as 100% where the work made great demands on employees' skill, exertion, responsibility, and endurance of disagreeable conditions. He considered 35% just for general machine shop work, and anything less than 20% not sufficiently attractive to be effective. For machine tenders who do not have to do much labor or exert extreme attention, 10% to 15% bonus is sufficient. For employees who have to use their eyes a great deal, as in silk processes, 30% to 40% may be necessary. For employees who have to use a great deal of skill or who have to do heavy work in addition to skilled work, 60% to 70% may be necessary.

The Day Guarantee.—The substitution of a day guarantee for the punitive low piece rate below task gave a feeling of security, much needed at that time, and is still desirable for many situations. As pointed out under the Manchester plan, the guarantee is not always necessary, and may even be dangerous. It causes less ambitious employees to be contented with the guaranteed amount. They are not likely to attempt their best and scatter widely below the task efficiency. In England a (25-75) constant sharing has been used below task in place of the horizontal day guarantee. As this curve lies between that of piece rate and that of day rate, it is particularly good for beginners. (See Figure 30.) There were two circumstances which made the guarantee consistent as applied by Gantt. In the first place, production control was just developing, and delays causing idleness were far more common than in the best managed shops today. In the second place, Gantt did not stop with financial incentives.

Man Record Charts.—It was characteristic of Gantt to think of employee psychology. He insisted on the principle of immediacy to make all cause and effect relationships definite. He recognized the employee's individuality and pride in reputation. He devised a chart which listed the employees at the left and divided the chart horizontally into units of time. This time scale was subdivided into the months of the year, the weeks and the days. If the employee did his work in task time or less, Gantt filled the space for that day opposite

his name in solid black. If not, he filled it in solid red. Where the employee was temporarily placed on day work, Gantt filled the space in with a black cross. If absent for a day, he indicated it by a red cross. This chart was posted and the amount of red became the measure of an individual's inefficiency. The charts were remarkable not only in showing a preponderance of the black, but in showing a constant decrease in the amount of red as time went on.

Pains Taken in Training Employees.—Furthermore, Gantt went beyond Taylor in training employees to make their tasks. In writing of this, Gantt used the expression "habits of industry." He thought it was the employer's responsibility not only to provide work and tools, but to take every pains in developing habits of industry for all employees, so that after a reasonable time they could make the tasks constantly.[1] Both Taylor and Gantt paid a separate bonus to the foremen. This made both the foremen and the men keep after the management to provide a continuous supply of work. Gantt even gave an additional bonus to the foreman when all his subordinates made their tasks. This insured every pains in the matter of training. The more complex Gantt chart for progress was later used as a basis for planning and control. The man-hour was the common denominator. The Gantt system of control can do about everything the Bedaux system can do and can do it graphically, which is even better. The fact is, however, that the man-hour seems less flexible than the "B" and is rarely used so extensively. In his last years, Gantt spent his whole effort arousing the management rather than in arousing employees, because he felt that there was much for the former to do before they could expect employees to make further increases.

Thus the Gantt plan is both humane and strong in its financial incentive. With the use of man record charts and proper training, the weakness of the day guarantee is minimized and the non-financial feature is given equal emphasis with the financial, making it one of the most successful plans to install wherever there have been either time rates or piece rates. For further analysis see Figures 25 and 26.

FORMULA FOR EARNING:

$$\text{Earning up to task} = \text{Hours Actual} \times \text{Rate per Hour}$$

$$E = H_a \quad R_h \qquad \text{(See time plan)}$$

$$\text{Earning at and above task} = \text{Hours Standard} \times \text{Rate per Hour} + 20\%\ \text{Hours Standard} \times \text{Rate per Hour}$$

$$E = H_s \quad R_h \quad + .20 \quad H_s \quad R_h$$

$$E = 1.20\, H_s\, R_h$$

[1] H. L. Gantt, A. S. M. E. Transactions, 1908.

Key to Symbols

E = Earning in dollars (the vertical variable)
H_s = Hours standard (the horizontal variable)
H_a = Hours actual (a constant)
R_h = Rate per hour in dollars (a constant)

Cost per Piece.—Costs for the Gantt plan are those shown under the time plan nearly up to task, and approximately those shown under the Merrick plan above task. The total cost per piece is, therefore, high for low production, of which there will be little, and low for high production, of which there will be a preponderance. As in the other step bonus plans, the total cost curve should ignore the steps as indicated by the smooth curve between the two actual curves.

Example of Task and Bonus Plan.—One of our electrical equipment companies used this plan many years under the erroneous name of "standard time" plan. The difference between the regular plan and the one here described is the amount of bonus at task and the level of the guaranteed day rate. The former is less and the latter is greater than in the original plan. The calculation is also changed from the time to the rate basis. These modifications do not require any change in name because no change in principle is involved. The plan does not belong to the time rate classification and no more is made of standard time or task than in many other plans. Suppose a lathe operator is to rough turn a motor shaft, the standard time for which is 3 hours. The man's ordinary hourly rate is $.60 and his corresponding high rate or standard time rate is $.67. He either does the job in more than 3 hours, example (a), or he does the job in 3 hours or less, example (b).

(a) Time taken 3½ hours, that is, he had a "fall down." His earning would be 3½ × $.60 = $2.10.

(b) Time taken 2½ hours, that is, he more than made task. His earning would be 3 × $.67 = $2.01, with an hour yet to work relative to (a). If he continues at the same efficiency to the end of 3½ hours, he would have $2.81. If he were paid on the true standard time plan, his earning under (a) would be the same, but under (b) it would be $2.35 for the 3½ hours. The lower hourly rate is merely a guarantee but is intended to be more generous than the usual time rate for this purpose. This is made necessary by the local difficulty of hiring skilled men. The higher rate is usually one-eighth above the base. There is no upper limit placed on earnings. Careful job standardization and job evaluation precede all assignments.

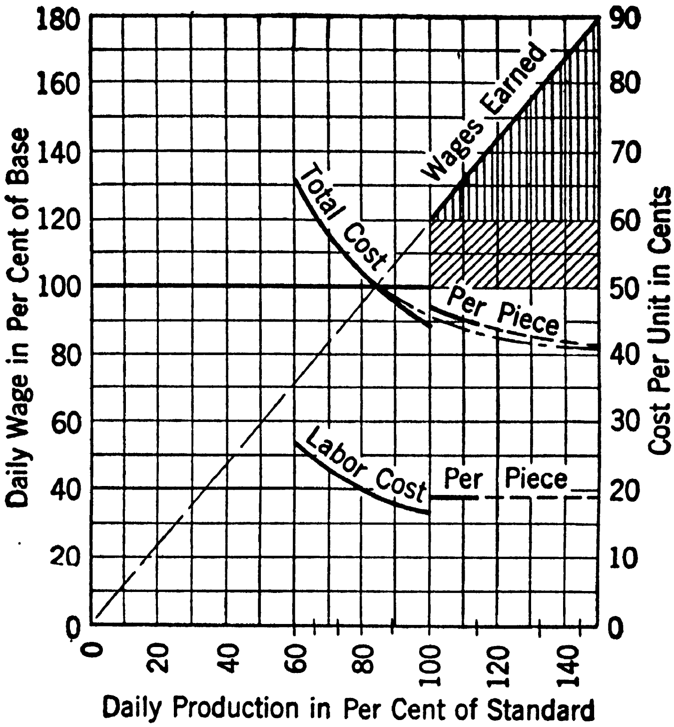


Figure 45. Gantt Task and Bonus Plan

TABLE 31. GANTT TASK AND BONUS DATA

Per Cent of Production H_s/H_a	Per Cent of Total to Base Wage for Full Day $E/H_a R_h$	Total Daily Wage in Dollars E	Number Pieces per Day	Time Saved per 8-Hr. Task in Hours $H_s - H_a$	Labor Cost per Piece in Dollars	Total Cost per Piece in Dollars
60	100	3.84	14.4	− 5.3	.27	.66
66	100	3.84	16.0	− 4.0	.24	.60
73	100	3.84	17.5	− 3.0	.22	.56
80	100	3.84	19.2	− 2.0	.20	.52
89	100	3.84	21.4	− 1.0	.18	.48
100	120	4.61	24.0	0.	.19	.47
114	137	5.26	27.4	1.0	.19	.45
133	160	6.14	32.0	2.0	.19	.43
145	174	6.68	34.8	2.5	.19	.42

Key Sheet.—This is a master sheet listing all the individual guarantee rates and corresponding standard time rates. This alone is modified for general readjustment in wages and the thousands of piece rates remain unchanged. The unit of value or time allowance is expressed in decimals of the hour.

Fall-Down Card.—When the time clerk receives the time slips, he promptly extends the elapsed time and in each case where this time is greater than the task time, he makes out a fall-down card showing the circumstances and causes of failure. These cards are forwarded to the time study analyst who in turn interviews the employees concerned. The failures due to causes outside the control of the operatives are checked off and covered by time payments. The foreman then goes over the cards, signs them, and sends them to the performance chart clerk. The latter makes a graphic record of the performance and sends these to the chief time study analyst for his scrutiny. They then go to the general foremen and back to the job standardization department for file and future use. This informs all the responsible parties as to the extent and cause of failures while also showing them the individual involved.

Advantages Claimed by the Management.—

It avoids the suspicion aroused by the sharing principle.

It is easy for employee to calculate his earnings.

There is great flexibility in the matter of wage adjustment.

It necessitates better planning and control.

Extent and cause of fall down is promptly known.

It affords a basis for checking efficiency of individuals.

Departments may be rated and compared.

More accurate and consistent time values have made possible more accurate and more uniform costs.

In practically every case where costs have been compared the costs have been less than under the previous premium plan.[2]

It has stimulated better supervision.

It is applicable to both standard and special lines of work.

Application of Gantt Plan to Textiles.—An eastern company operating five textile plants, installed this plan thirty-two years ago. The following details refer to two plants, one a bleachery, and one a dye works. Out of 1,800 on the payroll, 1,120 men and 250 women work under the plan. It is based on careful job standardization. The regular Gantt individual production records were used at first, but have now given way to simpler forms. With the present system of

[2] The incentive history for this company is outlined in Chapter 2.

paper work, only five clerks are needed in the factory and four in the office to take care of wages. Efficiencies go as high as 130% of task, and wages as high as 60% above base. The management cites as benefits: (a) it guarantees base wage for those who fail to make task; (b) it gives full earnings above task; (c) it simplifies management; (d) it reduces costs; (e) it increases production.

Another company still calls its plan Gantt task and bonus, but dispensed with half of the bonus by substituting a higher time rate when production reached 90% of task. This is like a Merrick plan with a day guarantee. As a result of good training 96.5% of the employees were always above 100% of the weekly task, 1.5% were between 90% and 100% task, and 2.0% were below 90% task. The steps were 10% and 10%. In 1930 this company raised all base rates $.10 per hour to keep the lowest rates above minimum requirements and avoid losing existing differentials. To offset this increased labor cost the company temporarily changed the piece rate above task to a 50-50 constant sharing rate. In other words, they fell back to a Diemer plan. In 1933 they changed that to a (100, 110) piece rate above task which connected with the intermediate day rate and eliminated the higher step (Figure 46, Table 32). This arrangement is still in effect at this writing and applies to nearly the entire plant except in the case of a few weavers who asked for, and were given, straight piece rate.

After making the change in 1930, the management commented as follows: "Prior to the introduction of this change in our wage payment, our gains over task had averaged about 15%. Shortly thereafter in some of the departments it was evident that employees, particularly those who had had high gains, figured out that it would be to their advantage to reduce those gains in order to spread the work over a longer period. This condition we followed up, and after a few months our gains came back from a low of about 11% to where they had been and beyond to a high of about 17%. From then on they have fluctuated up and down, usually going up as general industrial conditions appeared to be more promising and going down when things looked worse. They have, however, been held on the whole between 14% and 16%, and there they are at the present time.

"The advantages of this plan are that in these very difficult times it has served to balance the wages more evenly and hold up the necessity for decreasing the very low wages; also it has meant that all efforts to increase production by the removal of obstacles and assistance of all sorts from foremen must in each case result in a decrease in cost. On the other hand, the employees naturally prefer

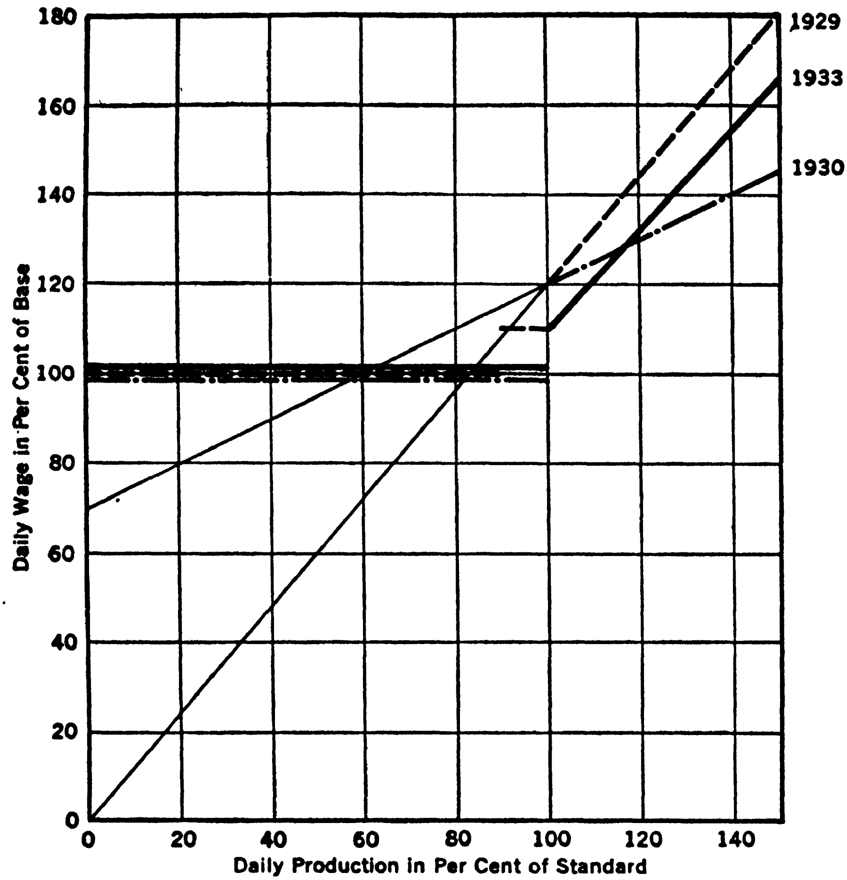


Figure 46. Changes Due to Depression, 1930 and 1933

TABLE 32. FORMULAS AS CHANGED 1930 AND 1933

	1929	1930	1933
To 90% task	$E = 1.00\, H_a R_h$ (base time rate)	$E = 1.00\, H_a R_h$ (base time rate)	$E = 1.00\, H_a R_h$ (base time rate)
90% to 100% task	$E = 1.10\, H_a R_h$ (intermediate time rate)	$E = 1.00\, H_a R_h$ (base time rate)	$E = 1.00\, H_a R_h$ (base time rate)
At and above 100% task	$E = 1.20\, H_s R_h$ (high piece rate)	$E = .50\, H_s R_h + .70\, H_s R_h$ (Diemer constant sharing)	$E = 1.10\, H_s R_h$ (intermediate piece rate)

to be paid at the same rate above the task as up to the task, and have urged us very strongly to go back to our old method. This, of course, would have meant an increase in wages, which up until this time (1933) has not been in order."

Soon after making this statement the company made the further change indicated on the chart by the date 1933 and management commented as follows:

"We have restored the full gain over the task of our original Gantt plan. The time during which the one-half gain plan appeared to be applicable seems passed; our Works Council very strongly urged the change, as did many of our supervisory force. On certain operations, chiefly for quality reasons, we shall place limits on the gains, some possibly 25%, some possibly 50%. On other operations, such as dyeing, where we wish for no incentives to cut down on the length of time in the dye liquors, we pay our bonus on time taken only.

"We have reduced our bonuses at the task by one-half. This was done in order to offset the effect of an increase in payroll. The cross-over point is at approximately 116% production, which is about our normal gain over the task. Thus the employees who gain more than 16% will benefit; those who gain less will lose by the change.

"Our habits of industry are so fixed by now that we have little question of the incentive of 10%, which would certainly seem too low if one were starting in a new plan. We shall now keep very close records of the relative accomplishment of task and of what we expect will be our somewhat increased gain."

The same executive writing us in 1941 indicates that the plan continues to work well under union agreement. "In saying that we have made no changes (since 1933) in principles, I do not mean that we have not had many occasions when we have gone over the question of incentives with our union representatives. We have often made studies together with them and adjusted tasks and methods in agreement with them."

Combined Manchester and Differential Time Plan.—A well-known company making paper products combines the Manchester and differential time principles into one plan[8] and applies it to groups of employees who have common interests. Each group of direct producers includes the machine adjuster and "make-ready" men serving them. Some 40 men and 200 women are affected out of a total of 2,500 on the payroll. The plan (Figure 47) was installed about thirty-two years ago and displaced individual incentives which did not bring the cooperation desired. The minute is used as the time

[8] This plan also evolved from an original Gantt installation.

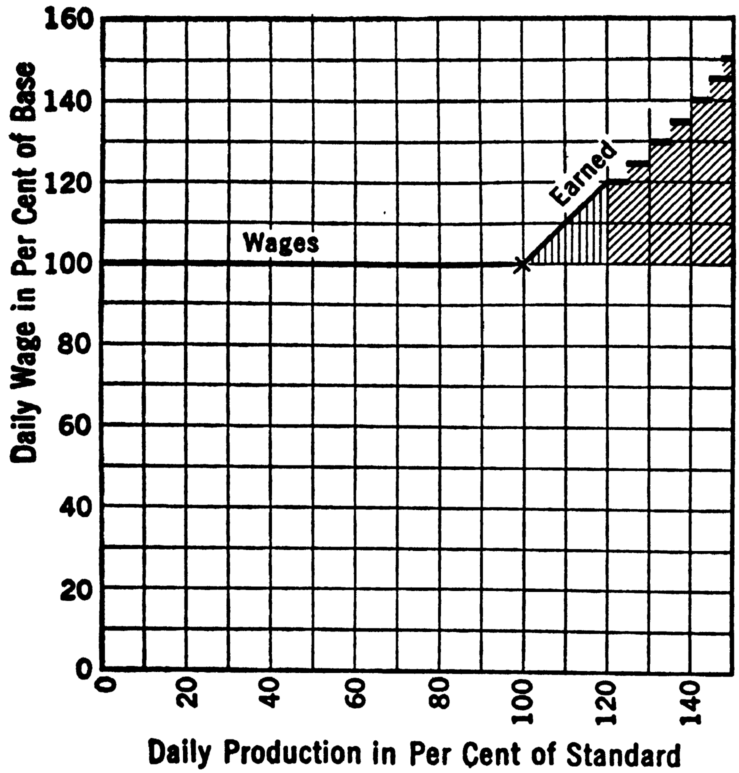


Figure 47. Combined Manchester and Differential Time Plan

unit. A time rate is guaranteed to 100% task, basic piece rate extends from there to 120% task, and above that evenly spaced steps are established between multiple time rates. The guaranteed time rate is generally somewhat less than the base time rate. Since a piece rate is inserted between 100% and 120% task, it is likely that the task is actually somewhat lower than true high task. The management expects the average operator to produce at least 120% of the task and therefore does not begin the series of "step" bonuses until that production is reached.

Claims for Plan.—It is claimed that the plan eliminates the differences of skill between operators, obviates minor delays, and insures uniformly high earnings. In short, it places the incentive on cooperation for production control as well as on reasonably high productivity. Tasks are based on careful job standardization, and individual production records are used as a guide to promotion. Tasks and rates are never changed until methods are changed. Costs are the same as for basic piece rate, but the steps assure greater response and steadiness. Calculations for this plan are given in detail in Tables 33 and 34.

TABLE 33. TIME ALLOWANCES FOR OPERATORS AND ADJUSTERS*

The following allowances are made for average work and for temporary operators and adjuster per period of 525 minutes.

Group Per Cent	Operator Man-Minutes per Day	Adjuster
120	630	340
125	656	352
130	683	368
135	709	382
140	735	396
145	760	411
150	787	425

* Above % nearest to group average is used.

Task and Bonus Applied to Salesmen.—The many factors mentioned under the point system are frequently defined as tasks or quotas and are given fixed rates which are paid in addition to salary. For instance, one sales organization pays for:

Each canvassing call	$.10
Each solicitation call	.05
Each demonstration call	.25

What is essentially a Gantt plan (Figure 48), has been applied to salesmen at a western cereal company. It happens that the first commission given is below the task location and comes directly from the guaranteed salary without a step, but all other common rates follow bonus steps. If this first commission were omitted and the salary guaranteed up to task, it would be a Gantt plan with additional rates. The additional rates are necessary in sales work because it is evident that a salesman has no upper limit to the amount of his "production" if he can get increasingly larger orders. It is, therefore, characteristic of all plans applied to sales that the chart is simply extended. For this reason, it would seem justifiable to have decreasing rates, but this one company believes largers orders sufficiently important to allow the rates to increase as shown on the chart. To further the size of order, the differential rate zones may be governed by the volume of individual orders rather than by the total volume.

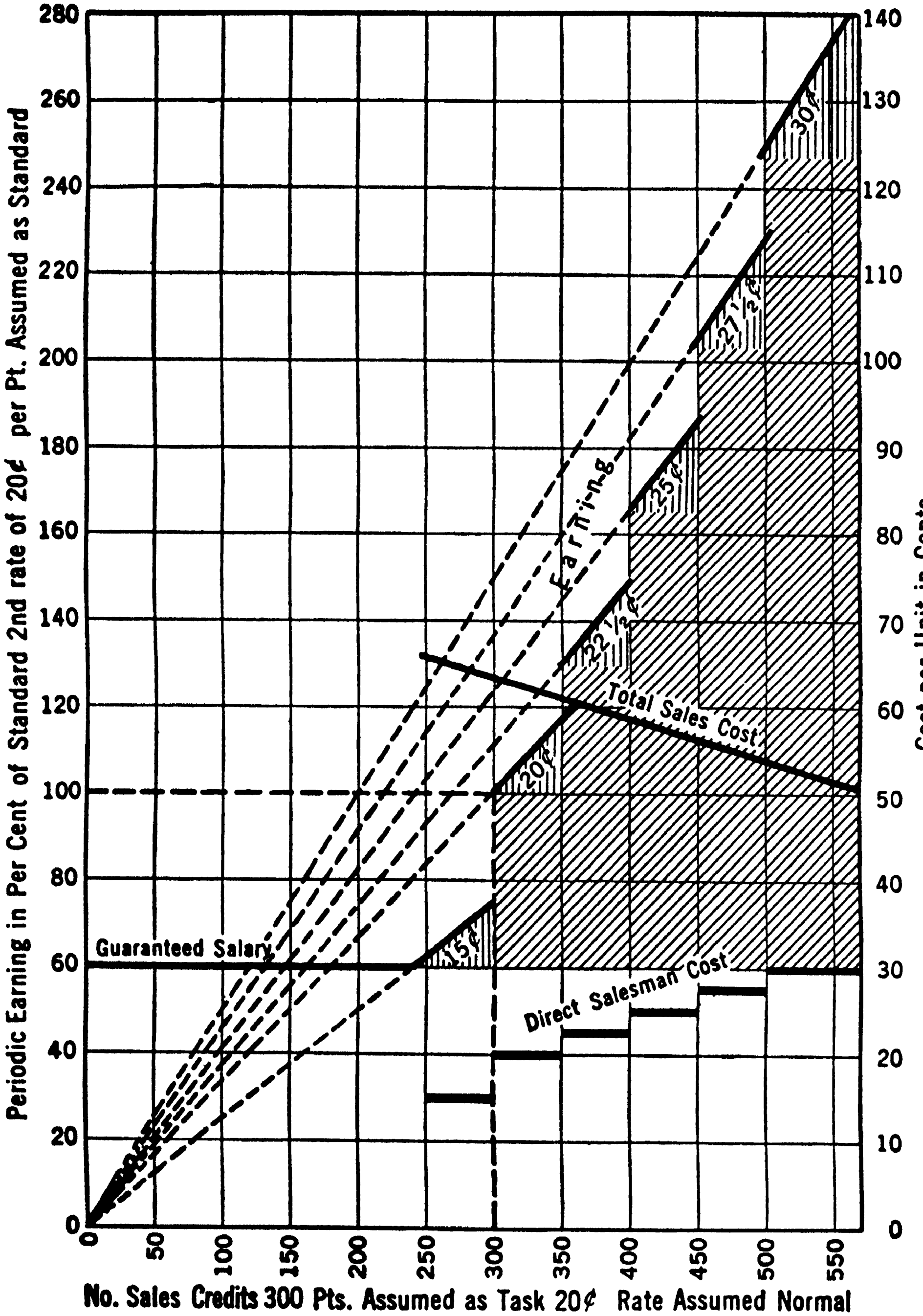


Figure 48. Multiple Commission Plan for Sales

TABLE 34. STANDARD METHOD SHEET FOR PRINTING JOB

DEPT. 16 DATE ISSUED No. 16–S–62

ITEM Group Rate on Small Stringers

OPERATION Set up, make ready, adjust and run small stringers.
Running small stringer for die out order—not strung.

SIZE 8 Small Stringers

MACHINE NO. SPEED As below

STANDARD TIME As below MIN. PER As below

CLASS Adjuster—A OPERATORS 6 girls—1 man

SAFETY PRECAUTIONS Usual

DETAIL SPECIFICATIONS FOR EQUIPMENT, MATERIAL, METHOD, RATE AND QUALITY

Remove previous die, get new die, put on machine and adjust:

Small die.......... 6 min.
Medium " .... 8 "
Large " .... 10 "

Change stock on order............3 min.
" string " " ....2 "

Change stock and string (same length as previous order) same die....10 min.
" " " " (change length) same die....17 "
" " " " new order which calls for die change.........35 "
(Plus die change)

Put on print—1 press............22 min.
" " " —2 " ....39 "
Wash one press only............. 5 min.
" " " and fountain......15 "
Change rollers—per press......... 6 "
Number change or one line change—per press.......... 8 min.
Change electros or linos—per press....................11 "

STANDARD TIME 22 MIN. PER set up

CLASS A and B OPERATORS 1 man—6 girls

SAFETY PRECAUTIONS Usual

Disconnect stringing head and set up machine for running tags which are not to be strung. If change of die is necessary allowance for die change will be added to above set-up time.

Running—110 min. per 10M—1/ Side print

TABLE 34 (*Continued*)

CONDITIONS:

1. Once each day at approximately the same time the total standard time allowed on jobs completed by group will be totalled up and the per cent productivity of group determined.
2. The order, stock and electros or linos (if any) will be delivered to machine when or before needed by adjuster.
3. Dies will be set up and sharpened by the die men.
4. All adjustments will be taken care of by the group except those now handled by machinists, such as repairing parts, etc.
5. Due to extra facilities available to group, there should be no time lost waiting for material or dies. If something is lacking on an order, this should be reported to foreman and another order started. No delay time will be allowed.
6. In case not enough work is available for full group, the adjuster will take the matter up with the foreman, and arrangements will be made to place operator or operators outside of group.
7. Time spent by operators on work outside of the group will be paid for at their rated average established on work done outside of group.
8. Substitutes will be provided when adjusters are absent.
9. Electro repairs will be cared for by someone in the department or sent to Dept. 10 by a messenger.
10. Allowance for adjusting has been made as described later in this rate.
11. Due out dates on orders must be maintained.
12. Adjuster will be responsible for setting up jobs and putting on print, unless the foreman assigns a printer to assist in putting on print. In the latter case the adjuster will not receive credit for work done by the printer.

METHOD:

1. Adjuster will make ready, make adjustments and string tags when not otherwise occupied.
2. Operators will string tags on any machine that is ready to operate.
3. Adjusters and operators must cooperate to obtain the maximum production from equipment and maintain due out dates on orders.

TABLE 34 (*Continued*)

METHOD OF PAYMENT:

1. There is a standard time allowance for each make ready and a standard time allowance per 10M for tags run on small stringers.
2. Every person in the group will have a group rate.
3. The time allowed on jobs completed by group in a given period divided by the total time spent by members in group during this same period will give per cent productivity of group.
4. Per cent productivity of group per week multiplied by group rate of individual members of group will give hourly earnings of each member.
5. Hourly earnings multiplied by the length of time spent in the group will give the earnings of a member.

METHOD OF FIGURING GROUP'S AND ADJUSTER'S PRODUCTIVITY:

Adjuster and group will receive 7.6% of the total standard minutes made by group to compensate the adjuster and group for the time adjuster spends adjusting machines.

EXAMPLE:

Total of 6 operators' standard minutes made during full day's work..	4,410
Adjuster's standard minutes (make readies, changes in print, etc.)....	370
Total	4,780
4,780 × .076	364
	5,144

$$\text{Group's productivity} = \frac{5{,}144}{7 \times 525} = \frac{5{,}144}{3{,}675} = 140\%$$

Suppose group makes 140% for week and operator's group rate is $20 per week.

Operator's pay for week = 20 × 1.40 = $28 for 40-hour week.

During the training period of new people the group will be credited with the following per cent allowance until the person becomes qualified to become one of the group. If a person in training makes higher per cent than the group is credited with, the group will be credited with a higher per cent. Persons in training will not share group earnings unless their weekly productivity is equivalent to or higher than the per cent the group is credited with for them.

Girl operator	133%
Adjuster	133%

TABLE 34 (*Continued*)

Allowances for operators and adjusters during their training period:

Full 8 hour day	698 min.
" 4 " "	339 "

During the adjuster's training period the group productivity will be figured as follows:

EXAMPLE:

Total of 6 operators' standards minutes made during full day's work	4,410
Adjuster's allowance	698
Total	5,108

$$\frac{5{,}108}{7 \times 525} = \frac{5{,}108}{3{,}675} = 139\%$$

Temporary operators or adjusters, filling in for absences or vacation periods will not be considered as part of group, but their productivity will be figured at the group average for the last six weeks' period.

CHAPTER 10

CONSTANT SHARING PLANS

> A comparatively small premium will call out a workman's best efforts, provided the work is not too laborious, and the workman is assured against future cuts in the rate.—F. A. HALSEY.

Towne Gain Sharing Plan.—The constant sharing or premium type of incentive originated independently of the Taylor movement and drew its inspiration from yearly profit sharing.[1] The practice of cutting piece rates was at its height and the Knights of Labor were giving employers considerable trouble. In 1886, Henry R. Towne,[2] of the Yale and Towne Manufacturing Company, decided to modify the usual profit sharing scheme to reflect the productivity of his manufacturing departments. He determined to use his cost system as a "basis for allotting to the employees in a business a share in the gain or benefit accruing from their own efforts, without involving in the account the general profits or losses of the business. . . . If at the end of the year the credits exceed the charges, I will divide the resulting gain, or reduction in cost, with you, retaining myself one portion, say one half—and distributing the other portion among you pro rata on the basis of the wages earned by each during the year."

The plan did not displace either day rate or piece rate, but applied in addition to them. It did not, however, amount to 50% of the saving as far as direct producers were concerned. Out of their half a certain amount, arbitrarily set, went to the foremen. "Assuming 50 employees under one foreman, I regard 10 to 15% of the profit fund as about the proper allotment to the foreman, leaving 40 to 35% for his subordinates, where 50% is retained by the employer." The plan retained the weakest feature of regular profit sharing, that is, the postponement to the end of a year of the payment of the rewards. Today such a procedure would not be looked upon as a true production incentive, but it did start a good deal of thinking and paved the way for the Halsey plan; Towne-Halsey gain sharing plan it was sometimes called.

[1] For instance, the Pennsylvania Railroad had a plan to lessen material waste as early as 1868. *The Iron Age,* November 20, 1930.
[2] A. S. M. E., 1888.

Halsey Premium, with Day Guarantee, but No Steps.—Frederick A. Halsey, an engineer employed by the Rand Drill Company, thought this sharing idea might be used as a weekly or even a daily incentive. About 1890, he started what he called the premium plan, at the Canadian Rand Drill Company. A point of production was to be set from the record of performances during past months. The time saved above this task was to be shared in some arithmetic proportion between the company and the men; the men's share was to be paid at the usual hourly rate. The task he set was naturally low, as time study had not yet come into use outside of Taylor's companies. When the men failed to make this task, they were paid their regular time wages which then amounted to $1.50 for a 10-hour day. Mr. Halsey did not at first think of making the sharing (50-50). In fact, he did not at first figure it on any percentage. He would simply tell a man that if he would do the job in the time indicated, he would give him $.05 an hour more as a premium. It happened that this $.05 amounted to 33⅓% of the usual wage. The plan was optional and was a success from the start, but no other company followed.[3] Not until 1898 was any further interest shown.[4]

The next year, Mr. Halsey published a paper which was noticed by the Builders' Iron Foundry Company of Providence.[5] This company installed the plan and after that it spread rapidly under the name Towne-Halsey plan. About 1900, the National Metal Trades Association recommended it. As its low earning slope applied without any sort of time study, it was the only form of incentive, besides old-fashioned piece rate, which was suitable to our conditions. Presentation of it was, therefore, a considerable achievement, and in recognition of this, Mr. Halsey was given a gold medal by the American Society of Mechanical Engineers in 1923.

Represented as a Partnership.—The amount of premium has always varied with individual applications, but it has come to be set generally at 50% of the time saved (Figure 49) because that can be presented to the employee as an equal and just partnership. Where the employee has always been on time wages, such a sharing is generous and is much appreciated. The (50-50) constant sharing principle, working "at the halves" as they say "down East," had been firmly established as a just distribution between master and men even before the Roman period in Europe. In England it had wide usage and was called the Mitayer system. It may have been fair

[3] Halsey, *The Premium Plan for Paying Labor*, A. S. M. E., 1891.

[4] That year Messrs. Weir of Cathcart, England, introduced the plan, using the (50-50) proportion of sharing. It is still occasionally called the Halsey-Weir or Weir System in that country. See also *Engineering Magazine*, 1901.

[5] A. S. M. E. Trans., Vol. 12, and *Sibley Journal of M. E.*, Vol. XVI.

when master and man were in balanced partnership but there is less basis for it today. One employer using this plan writes: "Our operators do not like the split time and we contemplate a change."

The only way a constant sharing plan may be more generous than a piece rate plan is by starting the earning curve through a lower task location. When this is done, it passes through a high earning field for productions below what we now call the high task. For such productions these plans provide higher wages than most piece rates, but the earning curve eventually intersects those of piece rates and is thereafter lower. Mr. Halsey was under no illusion that his plan was adequate for highest efficiency.

Supervision Premium.—Sometimes 40% of the company share, that is, 20% of the whole saving, is put into a fund to reward those who may increase production through direction or supervision. A large can company has done this in its western plant, dividing that again into 80%-20% shares. The 80% part of the fund goes to the supervision above mentioned. These individuals are called class A employees. The 20% of the fund goes to class B, or indirect foremen, clerks, and maintenance men. The premium in four plants varies from 5% to 17% of standard wages. The department foreman may go as high as $50 premium a month, and those of the B group as high as $24 premium a month. For applications of the Halsey plan to other indirect production work see Chapter 18.

Estimated Tasks Are Always Unreliable.—While this plan was feasible in former times when time study was unknown and meets certain conditions today, lack of carefully set standards has in many instances discredited it. For instance, if the tasks for several jobs are inequitably set, this becomes known by employees and foremen alike. The former will complain to the latter that they had a particularly mean job last time and should have a particularly easy one this time. In fact, the foreman himself, recognizing this state of affairs, is under the necessity of allocating the hard and easy jobs and finds it difficult to assign them without bickering. If the rates are also inequitably set, the bickering may grow to serious connivance. Where men make out their own time cards, there is every temptation to let some hard task go beyond the required time so as to record some other job below the required time. By the time the records get to the office, everything seems to be going smoothly and equitably but out in the shop it may be anything but smooth or equitable. In short, even a correct slope for low task does not mean that job standardization is undesirable. An executive of a well-known western corporation writes:

"This year an attempt was made to apply the Halsey premium plan to the workmen in our shops, but it was discontinued, not because the plan is theoretically incorrect, but because it was applied without previously correcting conditions throughout the shops and because it was not based on accurately obtained standard time."

Plan Now Used with Time-Studied Tasks.—Despite all this, the plan is still in wide use because of the psychological value of creating a feeling of partnership. More than one industrialist of today is using this principle perhaps with a slightly different percentage of sharing and heralding it as something new. The arithmetic fractions of sharing to the employee range all the way up to 85% of the saving. One small machine company uses the (50-50) sharing for hand jobs and the (33⅓-66⅔) sharing for machine jobs in the same departments. At 100%, it becomes the old-fashioned piece rate on a time basis. It should be noted that the proportion of sharing determines the intercept on the earning axis of the graphs when the earning curve is extended. The less the sharing ratio to the employee, the higher the intercept. In other words, the limits are day wages with no sharing on the one side and piece rate with maximum sharing on the other.

Finally, there is no reason why even the low task cannot be carefully set. This is actually being done, but the fact is, that when a company goes to the trouble of making good time studies, it usually prefers to set the task high and use the sharper slope type of incentive. Where piece rate has been employed, the plan has little excuse and may be interpreted by the employee as an enforced sharing of his saving with the employer, that is, he may know that on piece rate he would receive all the saving. This is evident if we replace the arithmetic fraction by unity; see piece rates.

FORMULA FOR EARNING: (in terms of low task abscissa)

Earning up to low task = Hours Actual × Rate per Hour

$$E = H_a \; R_h$$

Earning at and above low task = Time Wages + Hours Saved × A fraction of the rate per hour

$$E = H_a R_h + (H_s - H_a) \; \frac{R_h}{4} \; . \; . \; . \text{ to } \frac{3R_h}{4}$$

Where fraction is ½, $E = R_h \dfrac{(H_a + H_s)}{2}$ relative to low task,

or in terms of high task abscissa

$$E = .8 \, H_s R_h + .5 \, H_a R_h$$

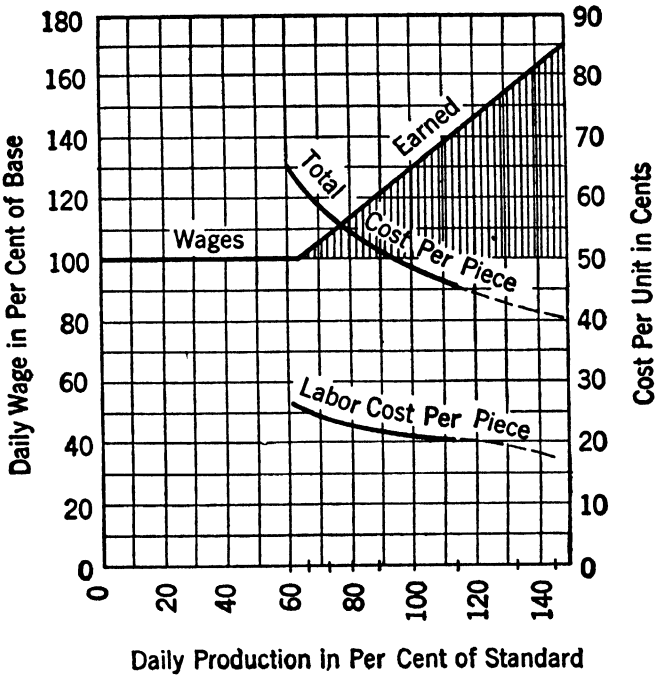


Figure 49. Halsey (50-50) Constant Sharing Plan

TABLE 35. HALSEY (50–50) CONSTANT SHARING DATA

Per Cent of Production H_s/H_a	Per Cent of Total to Base Wage for Full Day $E/H_a R_h$	Total Daily Wage in Dollars E	Number Pieces per Day	Time Saved per 8-Hr. Task in Hours $H_s - H_a$	Labor Cost per Piece in Dollars	Total Cost per Piece in Dollars
60 (96)*	100	3.84	14.4	− 5.3 (− 0.33)*	.27	.66
66 (107)	103	3.98	16.0	− 4.0 (0.50)	.25	.61
73 (116)	109	4.17	17.5	− 3.0 (1.125)	.24	.58
80 (128)	114	4.38	19.2	− 2.0 (1.75)	.23	.55
89 (143)	121	4.66	21.4	− 1.0 (2.375)	.22	.52
100 (160)	130	5.00	24.0	0. (3.00)	.21	.49
114 (183)	142	5.42	27.4	1.0 (3.625)	.20	.46
133 (213)	156	6.00	32.0	2.0 (4.25)	.19	.43
145 (232)	166	6.38	34.8	2.5 (4.55)	.18	.41

* A secondary efficiency scale is made necessary by the use of (100) for low task. See Chapter 4.

When the fraction of ½ is used, the earning is the algebraic mean between time earnings and piece earnings and equal to the latter when $H_a = H_s$.

The figures in Table 35 are made to correspond to the same production points used in the other plans, but the production efficiencies are in terms of the lower task as 100%. For the sake of comparison, these are given in parentheses opposite the regular efficiencies as given in the other tables. For explanation of the derivation of this table see Chapter 4, Methods of Studying Incentive Plans.

Key to Symbols

E = Earning in dollars (the vertical variable)
H_s = Hours standard (the horizontal variable)
H_a = Hours actual (a constant)
R_h = Rate per hour in dollars (a constant)

Cost per Piece.—The cost per piece under the Halsey (50-50) sharing plan is theoretically low, but, as in the case of time wages, the highest productions are seldom reached. The total unit cost for any time guaranteeing plan, which is not strong enough to keep average response above task, is high for the production attained. Drury cites average response as 85%.

Example of Halsey Plan.—A western jobbing foundry and machinery company has an installation which is well interwoven with its production control as all incentives should be. The company employs 375 men all of whom, including pattern makers, are on premium work and have been so since 1924. Originally the earned premiums were not paid until the order involved was completed delaying the payment from two weeks to six months, but at the time of writing the management is planning to pay every week. The fact that the plan was successful despite this drawback indicates, all the more, the importance of the tie-in with production control. Individual production records are kept, and the more energetic men are promoted; some eventually become foremen. The less energetic men who fail to make their tasks are obliged to fill out excess labor tickets stating reasons for the failures. This is good psychology.

Of the company's 50% share, 1/10 goes to the foremen who are thereby stimulated to do all they can to increase the departmental efficiency. The management claims that the typical efficiency relative to high task is around 85%, and earning 20% above the hourly rate. The low task is set by a time study staff known as the estimating department. It is a unique company, in that it is the manu-

facturing plant of five distinctly competitive concerns which constitute the only customers. Four or five hundred different orders may be in process simultaneously. The main interest is, however, the interlocking of the incentive with the other phases of management. Many incentives are weak in this respect. The management attributes much of the success of this program to the incentive plan. "It ties in with the production in an extremely important manner, as it gives us control of our machine hours, pays our men an incentive, helps us keep better men on the job, helps us to eliminate inefficient employees, and keeps our customers satisfied by giving them the maximum production at a minimum cost."

Example of Constant Sharing Without Day Guarantee.—A straight (33⅓-66⅔) constant sharing plan has been used since 1918 by a western gas and coke company in a plant having from 300 to 500 employees. A straight line earning curve of low slope (Figure 50) is passed through the low task day wage point (62½, 100) and made to extend back to zero production as well as up to 400% low task, which is 250% of high task. The company set up standards suitable to the topography, weather, and labor market conditions of its district. It used Halsey's original one-third sharing ratio on the theory that one-third saving pays for expense of operation and the remaining two-thirds should be divided equally between the company and the employees. Individual production records were kept and the premiums ranged from 10% to 40% of the base wage. This gave an estimated annual net saving to the company of $70,000. Production was increased and steadied. Quality and safety by no means suffered. Loyalty and cooperation distinctly increased. The company has also done a particularly thorough job in printing a full set of production standards.

Administration of the Plan.—The day wage is actually paid in all cases, except to beginners. The lower part of the curve is applied indirectly by postponing premiums until they exceed the amount of lost time. For the employee who has no lost time, earning amounts to a one-third sharing above low task. For the employee who has some lost time but more saved time, it amounts to a day guarantee up to a point varying around high task, after which his earnings jump from day wage to that of one-third sharing. For the beginner it provides an excellent scale of production earning through the low efficiencies leading on to higher amounts without any change of plan. There are only a few other plans in use, Barth, Bigelow-Knoeppel, the English (25-75) constant sharing, and the accelerating premium curves, which enter here between day and piece wages.

The areas L and G on the accompanying chart (Figure 50) illustrate the extreme case of a man who is but 25% efficient, high task, for half a day and 100% efficient, high task, for the other half. This man would then receive exactly day wages, the loss offsetting all the gain. If he continued at 100% efficiency, high task, for the next day, he would receive 20% extra wages for that day. As the premium is paid but once each month, it is rare that any employee does not have more time saved than time lost, so that the earning is usually on the one-third sharing line. One-third sharing means relative to full saving by the piece rate through the low task point (62½, 100). For the specific case above, it would, of course, be more than full saving relative to basic piece rate and exactly full saving for the Gantt-Merrick piece rate. Due to the use of low task, this earning curve would not be crossed by basic piece rate until 142% efficiency, high task. It would, however, be crossed by high piece rate at point (100, 120) and is therefore not as generous for high productions as a high piece rate. The fear of penalty is involved, so that it is more negative than its close competitor, the Diemer plan, which is certainly positive. As the latter starts from an intercept of 70% and the present plan from 66⅔, their intersection at the (100, 120) point makes the Diemer plan slightly lower above task despite its (50-50) sharing relative to basic piece rate. Like piece rate, a premium plan with no day guarantee lacks any special emphasis on its task amount of production. The relation may be understood best by an efficiency scale as in the empiric plans. Except for the penalty feature and delayed payment this plan represents the correct use of the low task low slope type of earning. It is said to be simple in operation and very satisfactory under favorable circumstances. About one clerk is required to fifty employees.

FORMULA FOR EARNING:

$$\text{Earning} = \text{Time Wages} + \tfrac{1}{3}\ \text{Wages Saved}$$

$$E = H_a R_h + \frac{(H_s - H_a) R_h}{3}$$

$$E = \frac{(2 H_a + H_s) R_h}{3} \text{ relative to low task}$$

or in terms of high task abscissas

$$E = .53\tfrac{1}{3}\, H_s R_h + .66\tfrac{2}{3}\, H_a R_h$$

Since the vertical intercept is above the legal minimum in most cases, this plan can be used instead of a 100% $H_a R_h$ guarantee. Thus some incentive can be carried to the lowest points of efficiency.

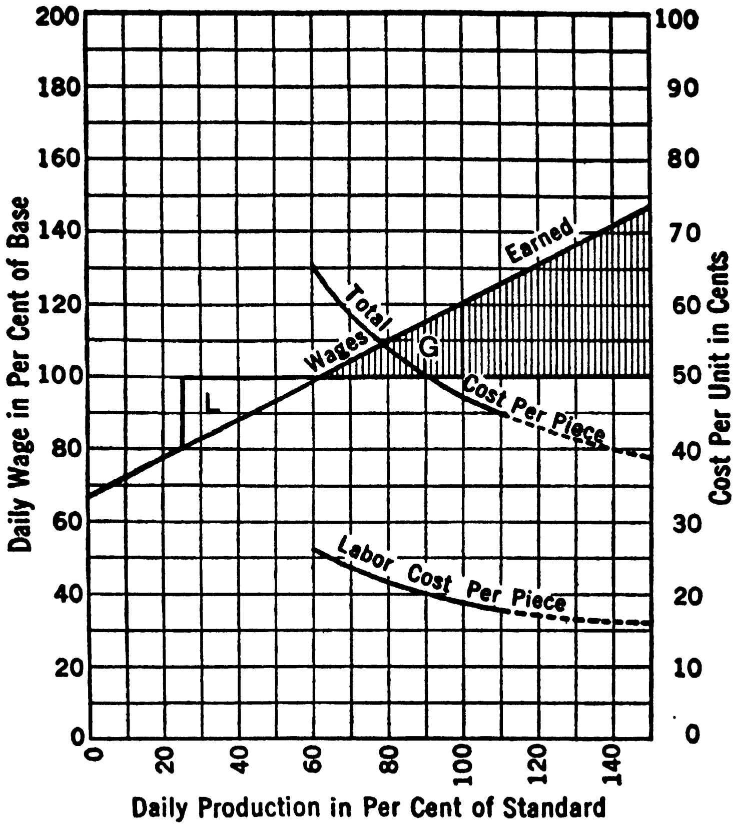


Figure 50. The Straight (33⅓-66⅔) Constant Sharing Plan

TABLE 36. THE STRAIGHT (33⅓–66⅔) CONSTANT SHARING DATA

Per Cent of Production H_s/H_a	Per Cent of Total to Base Wage for Full Day $E/H_a R_h$	Total Daily Wage in Dollars E	Number Pieces per Day	Time Saved per 8-Hr. Task in Hours $H_s - H_a$	Labor Cost per Piece in Dollars	Total Cost per Piece in Dollars
60 (96)	98	3.79	14.4	− 5.3 (− 0.33)	.26	.65
66 (107)	102	3.93	16.0	− 4.0 (0.50)	.25	.61
73 (116)	105	4.05	17.5	− 3.0 (1.125)	.23	.57
80 (128)	109	4.20	19.2	− 2.0 (1.75)	.22	.54
89 (143)	114	4.39	21.4	− 1.0 (2.375)	.20	.50
100 (160)	120	4.61	24.0	0. (3.00)	.19	.47
114 (183)	128	4.91	27.4	1.0 (3.625)	.18	.44
133 (213)	138	5.28	32.0	2.0 (4.25)	.17	.41
145 (232)	144	5.53	34.8	2.5 (4.55)	.16	.39

Cost per Piece.—The total cost per piece of the straight (33⅓-66⅔) constant sharing plan is much lower than for the (50-50) sharing plan and the plan is about that much the weaker for all but low efficiencies. It is simply a matter of what the employees have been used to earning or what they think they should earn. If they have been on day wages, those above 62½% efficient may appreciate this incentive and do considerably better under it. They should not, however, be expected to release their energies to any great extent. Like day work, therefore, its economy is hypothetical. The cost level actually reached on the average is pretty sure to be higher than under a more generous incentive. We recommend it for efficiencies below 62½%, that is, as a guarantee. If tasks are very low it may be suitable for higher efficiencies.

Example of Low Constant Sharing Plan.—A small eastern company, making electrical devices for airplane radios, furnishes a case which may not be unique in times of intensified defense efforts. The problem came from a hastily contrived assembly line. Conditions were studied by an industrial engineer[6] who found that the following problems were involved in the selection or design of a wage payment plan:

1. The quality of the unit must be maintained.
2. Payments must start at the low task at which the line has been working.
3. The union contract specifies that the crew must be able to earn 30% above their hourly rate.
4. The plan must pay on the number of units that pass government inspection.
5. Since the government determines the time at which the units must be inspected, the plan must pay on a weekly basis.
6. The computation of wages must be made simple to keep down the cost of administration.
7. The procedure by which the office is notified of payment must be simple and theft deterring.

Procedure for Design.—The following is the solution to the problems (conditions to be met) of this situation:

1. The magnitude of the premium per piece must not be so large as to cause lowering of quality of workmanship. The plan must not pay for pieces that do not pass government inspection due solely to poor workmanship.

[6] E. Norman Kagan, who at that time was studying wage incentives in a graduate class under the author.

2. A starting point must be selected slightly above but not far from the locus of past output.
3. The workers must earn 30% above hourly rate at new time study task (taken as 100%).
4. The inspector's report should be used as pay ticket to the cashier (additional copy made).
5. The bonus chart and work days must be set on a weekly basis, with the start of the week coinciding with the start of the inspection week.
6. An equation must be set up in simple form so that a bookkeeper can run the values off with a calculator and accurately calculate the payroll.
7. A foreman's report should be checked against the inspector's report to the government to assure the company that no cheating can occur.

It was soon decided that a constant sharing plan would best meet these requirements. A chart was drawn up, using 130 units per day as low or starting task for premium point (56, 100) and 240 units per day, the time study or high task for the 30% earnings, point (100, 130). A straight line was drawn between these points, representing the actual earnings. The slope of this line is the share of the savings in labor cost above starting, or low task, that the worker on the job will receive (Figure 51).

Derivation of Working Formulas for Plan

Key to Symbols

C_s = Standard cost at low task per piece
C_a = Actual cost above low task per piece
N_d = Number of pieces produced in one day
P_{rd} = Premium payment per operator per day

$$\text{Slope } m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{15}{23.4} = .351$$

virtually a (35-65) constant sharing.

Savings in labor per piece $(C_s - C_a)$ (1)
Savings in labor per day $(C_s - C_a)\, N_d$ (2)
$P_{rd} = .351\, (C_s - C_a)\, N_d$ (3)

$$C_s = \frac{\text{Hourly rate} \times 8 \text{ hrs.}}{\text{Output at low task}} = \frac{.375\ (8)}{130} \tag{4}$$

$$C_a = \frac{\text{Hourly rate} \times 8 \text{ hrs.}}{\text{Actual output per day}} = \frac{.375\ (8)}{N_d} \tag{5}$$

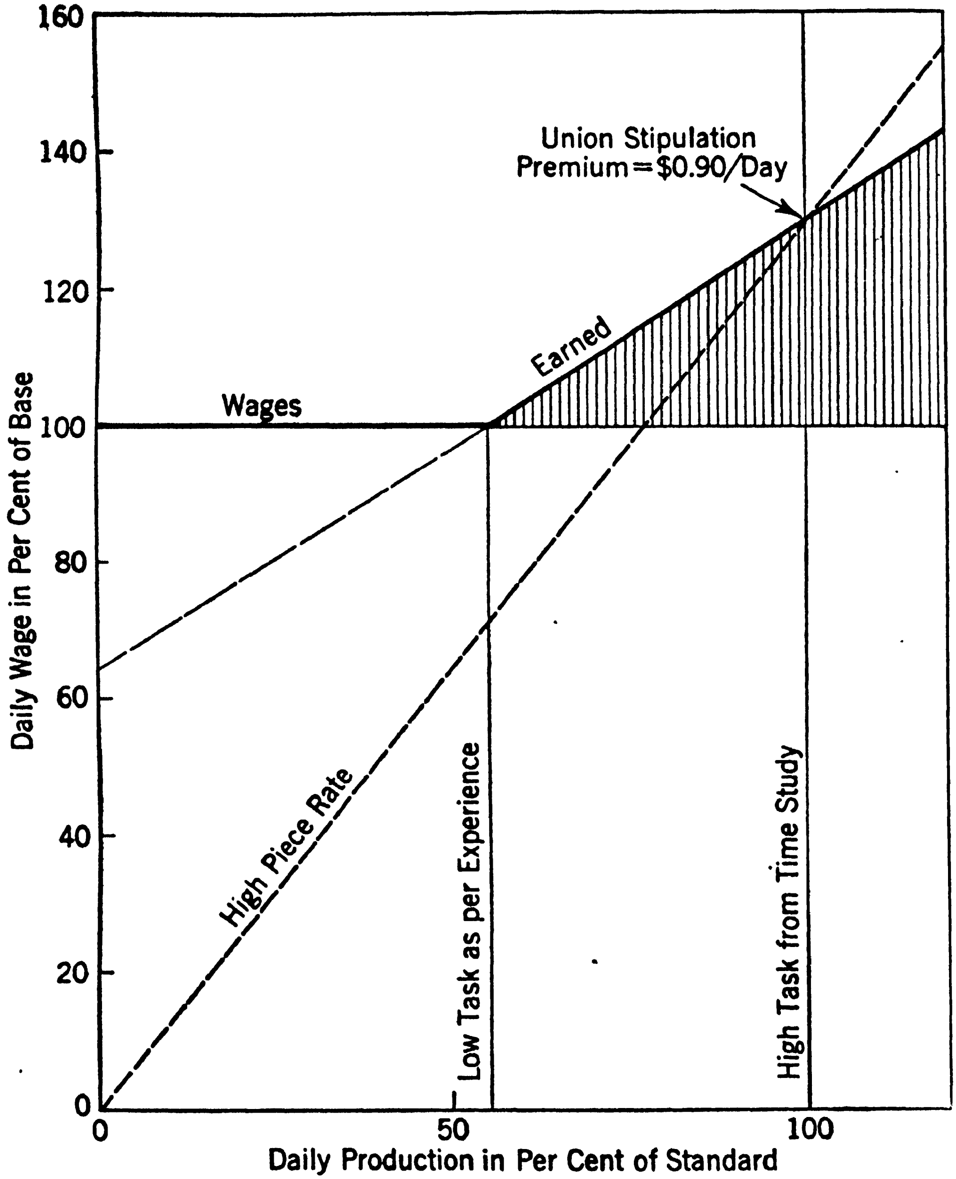


Figure 51. Low Slope Constant Sharing Plan from 56,100 up

TABLE 37. SAMPLE TABULATION FOR CALCULATIONS*

N_d	× .00808	− 1.05	× 5 (Premium)	$5N_d$ (Ave. Prod.)
130	1.05	000	000	650
160	1.292	.242	1.21	800
210	1.680	.63	3.15	1,050
240	1.940	.89	4.45	1,200
275	2.22	1.17	5.85	1,375

* A full two-column table of units produced and corresponding premiums were made for the payroll department.

Substituting: $P_{rd} = .351 \frac{.375\ (8)}{130} - \frac{.375\ (8)\ N_d}{N_d}$ (6)

Solving: $P_{rd} = .00808\ N_d - 1.05$ or Daily Premium (7)

Weekly Premium must be summation of 5 days:

$$5\ P_{rd} = 5\ (.00808 - 1.05) \quad (8)$$

$$P_{rd} = .351\ (C_s - C_a)\ N_d \quad (9)$$

$$\text{or } E = H_a\ R_h + .351\ (H_s - H_a)\ R_h$$

Cost Survey of Assembly Line.—Average output before new methods and premium installation was 600 units per week. Direct final assembly labor cost, including cost of supervision, was \$190.40.

$$\frac{190.40}{600} = \$.317 \text{ direct final assembly and supervision labor cost per unit}$$

Cost per unit at 1,200 units per week under new methods and premium,

$4.44 premium payment per person × 13 = $ 57.70
13 = 12 + 1 (for supervisor) 190.40

$$\frac{248.10}{1200} = \$.2065 \text{ direct final assembly and supervision labor cost per unit}$$

$$\frac{100 \times (.317 - .2065)}{.2065} = 53.5\% \text{ savings}$$

The total dollar value or savings after all charges had been added was \$342 per week. The per cent increase in wages of employees,

$$\frac{\$4.44}{\$15.00} = .298\ (100) = 29.8\% \text{ increase}$$

Factors Not Always the Same as Shares.—Various "shares" are sometimes used for various conditions in the same factory, the so-called share being represented as a factor F. All of these are made to pass through some desired efficiency-earning point. When this point is (100, 100) the factor and the share are identical but when some other point is assumed, as one company has assumed, the intercept on the earning axis, or employer's share $B\ H_a\ R_h\ (1.00\text{-}F)$, will not equal the factor. Suppose the assumed point is (100, 112), that is, $B = 1.12$, and the factor 10%. Then $1.12\ H_a\ R_h\ (1.00-.10) = 1.01\ H_a\ R_h$ and the earning curve will be entirely above the 1.00 base wage line (Figure 52). Neither is this the same as drawing the line parallel to the (10-90) sharing line for (100, 100), but the employee share is slightly greater thereby, 12% rather than 10%.

For all efficiencies up to task a low premium is a fair incentive. If used beyond task it is not likely to incite anything but discontent. We present it as a possible substitute for time rate wherever that is used up to task.

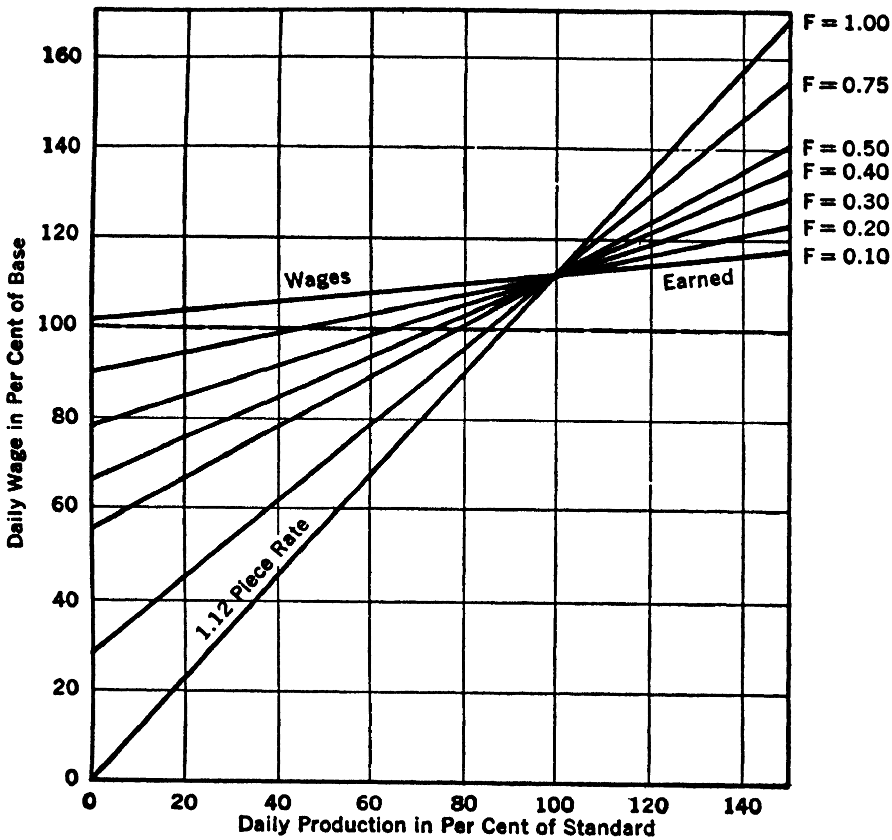


Figure 52. Use of Factors Instead of Shares

If $F = .20$ then the intercept will be 90 and will give a 10% share but on top of 90% of base. When $F = .30$ the share is 22%, that is, from 78% intercept, etc. Thus these earning lines start lower as the factor and real share increase. In short, the lines pivot about the assumed earning-efficiency point, and do not originate at the sharing intercepts. Hence these factors have an entirely different significance than the bona fide sharing fractions. Furthermore, if some jobs require higher incentives above task than do other jobs, why make the former take lower incentives below task? The common percentage earning at task might be justified by the hope of obtaining standard labor costs at task, but without step bonuses that hope is vain. For indirect labor such curves have been satisfactory above task, that is, with time guarantee below and bonus at task.

Diemer Premium with Day Guarantee and One Step Bonus.—Hugo Diemer, a consulting industrial engineer, felt that the Halsey premium plan was good in many respects but not adequate for the higher productions. While with the Atlas Engine Works of Indianapolis during 1904-1905, he modified the Halsey plan to conform more nearly with the ideas of Taylor. First, he established high task by time study, and second, he postponed the (50-50) constant sharing until after a step bonus was earned at the high task.[7] This plan (Figure 53) is like the Baum plans on the one hand, in that it is a case of constant sharing with a single step, and like the Gantt plan, in that it has the three main features of guaranteed time wages to high task, a sizable step bonus of 20% at 100% production, and a straight line increasing incentive beyond. It is in this latter feature that the plan is weak, few employees considering the (50-50) sharing or low slope earning of this misplaced curve consistent with the increasing effort involved in higher productions, and declining to go beyond the location of the step.

In short, why should we not use the piece rate as the Gantt plan does? If it is a matter of affording less generous reward, use the high time rate passing the (100, 120) point as does the standard time plan, because the step bonus is just as effective in that plan. It happens that above task it is about the average of all modern incentives, but we do not consider that being average is of itself any merit in an incentive for high production. If the Gantt plan had not already been in use three years, the Diemer plan would have made a certain contribution, but it is only slightly different, and is inferior to the Gantt plan in proportion to its difference.

FORMULA FOR EARNING:

Earning up to task = Hours Actual × Rate per Hour

$$E = H_a \quad R_h$$

Earning at and above task

$$= \text{Time Wages} + 20\%\ \text{Time Wages} + \tfrac{1}{2}\ \text{Savings}$$

$$E = H_a R_h + 20\%\, H_a R_h + (H_s - H_a)\frac{R_h}{2}$$

Simplified, $$E = (5\,H_s + 7\,H_a)\frac{R_h}{10}$$

or in the form $$y = mx + b$$

$$E = \frac{1}{2} H_s R_h + \frac{7}{10} H_a R_h$$

The E intercept of 7/10 is the result of 5/10 sharing and 2/10 bonus added.

[7] *The Engineering Magazine*, Vol. 29, 1905. *Factory Organization and Administration*, by Hugo Diemer, last edition.

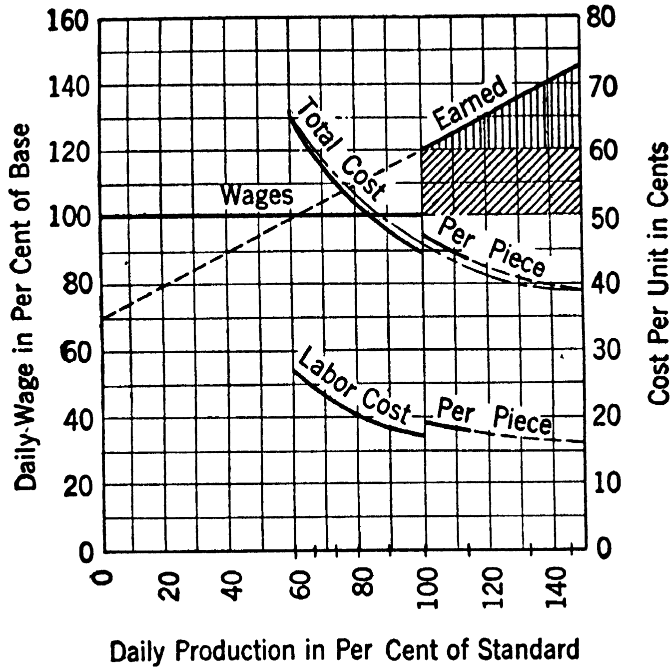


Figure 53. Diemer Premium and Bonus Plan—Based on 50-50 Constant Sharing Above High Task

TABLE 38. DIEMER PREMIUM AND BONUS DATA

Per Cent of Production H_s/H_a	Per Cent of Total to Base Wage for Full Day $E/H_a R_h$	Total Daily Wage in Dollars E	Number Pieces per Day	Time Saved per 8-Hr. Task in Hours $H_s - H_a$	Labor Cost per Piece in Dollars	Total Cost per Piece in Dollars
60	100	3.84	14.4	− 5.3	.27	.66
66	100	3.84	16.0	− 4.0	.24	.60
73	100	3.84	17.5	− 3.0	.22	.56
80	100	3.84	19.2	− 2.0	.20	.52
89	100	3.84	21.4	− 1.0	.18	.48
100	120	4.61	24.0	0.	.19	.47
114	127	4.88	27.4	1.0	.18	.44
133	136	5.25	32.0	2.0	.16	.40
145	142	5.46	34.8	2.5	.16	.37

The reader may wonder how this plan and the Halsey plan can both have (50-50) sharing and yet be so different in slope. The explanation is that the (50-50) sharing refers to two different piece rates, one for low task ($62\frac{1}{2}$, 100) and one for high task (100, 100). The tables are made different by "correcting" the task in the Halsey plan. The low slope characteristic of the sharing plans is unsuited to the high task. Note that the ($33\frac{1}{3}$-$66\frac{2}{3}$) constant sharing plan which uses the low task, nearly coincides with the Diemer plan above high task and is, in fact, slightly more generous above point (100, 120)!

Cost per Piece.—The cost per piece of the Diemer plan is similar to that of the Gantt plan. The cost would appear to be less for production above task except for the fact that a much smaller percentage of employees would be found far above the step. The cost above task is definitely more than for the standard time plan without superior prospect of response. The Diemer plan requires from 13 to 16 clerks per 1,000 employees.

10% Bonus and True (50-50) Sharing Plan.—A large textile plant which originally had a regular Gantt plan, modified the earning curve to a true 50-50 constant sharing plan but retained the high task and a 10% step bonus at that task. Since the intercept is .5, it is a true Halsey sharing curve, but this earning curve gives basic wages at 5/6th of high task. The higher task more than offsets the small bonus, that is, the earning is less generous than those of the Halsey or Diemer plans. Figure 54 shows this plan and illustrates why the earning amounts should not be taken from the chart as vertical dimensions, unless one is careful. For instance, it would appear that any earning above task should equal the total (1.10) $H_a R_h$ amounts at task plus a half sharing .5 $(H_s - H_a) R_h$, but that does not give a correct answer; does not check with the .6 $H_s R_h$ plus the intercept amount of time wages .5 $H_a R_h$ which gives the correct formula. The reason is that the premium curve crosses the base time wage line at 83.3% rather than at 100%. In all such cases the coefficient of sharing, in this case .6 $(H_s - H_a) R_h$, is not the same as the intercept or true per cent of sharing. Hence the safe way is to use the slope formula:

$$m = \frac{y_2 - y_1}{x_2 - x_1}$$

in which case $$m = \frac{1.1 - .5}{100 - 0} = .6$$

and $$y = mx + b$$

$$\frac{E}{H_a R_h} = .6\frac{H_s}{H_a} + .5$$

$$E = .6\, H_s R_h + .5\, H_a R_h$$

See Chapter 4, paragraph "The Formula Must Also Be Corrected to Conform" (page 116).

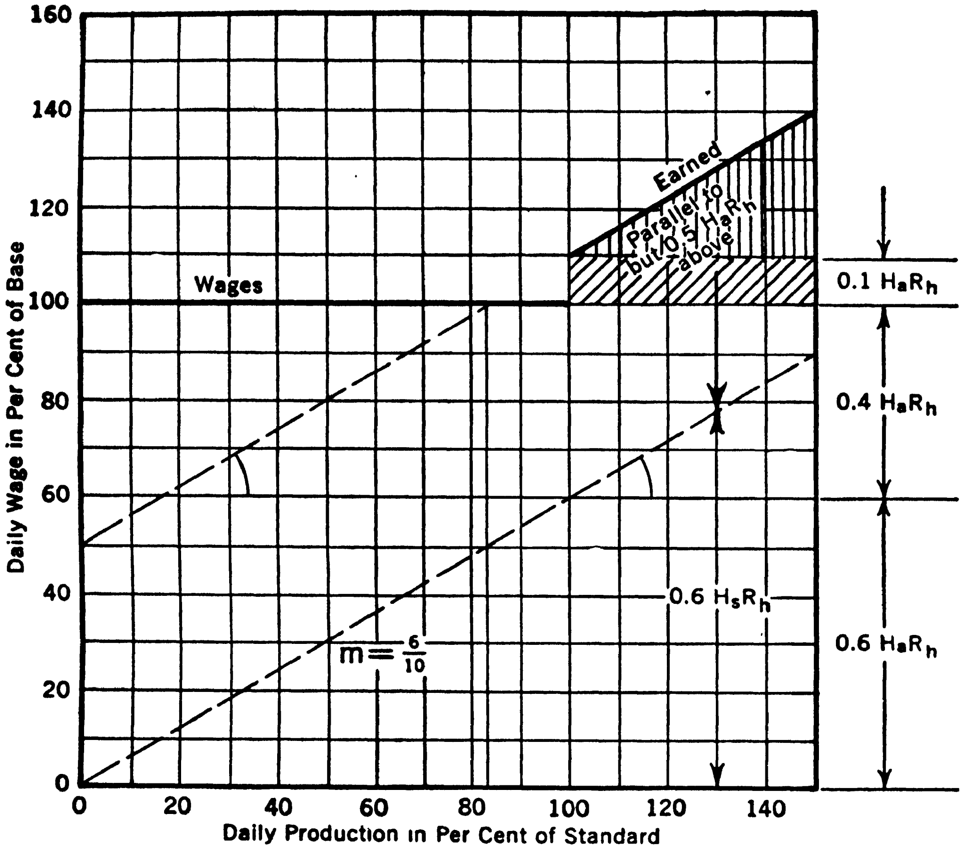


Figure 54. 10% Bonus and True (50-50) Sharing Plan

Example of Diemer Type of Plan.—The Smith and Furbush Company of Philadelphia employed Mr. Barth on management work about 1906 or 1907. Not long afterward, this company came under the control of the Philadelphia Textile Company. The latter company had in its employ engineers who had been with the Link Belt Company, where Mr. Merrick was installing Taylor methods. As a result of these Taylor influences, an excellent system of management was installed which needed little change, when a further consolidation about 1920 gave these units the name of the Proctor and Schwartz Company.

The wage plan, as it has survived, is in appearance like the Diemer plan, although in no way indebted to Mr. Diemer. As the

plan used a (50-50) constant sharing rather than a piece rate, the tasks were never made as high as specified by Diemer. While low standards are usually due to neglect and therefore undesirable, in this case they are deliberate and suitable to the earning slope used. With this early start for the earning curve and with the 30% step which is given at that task, the plan is very generous through the essential range of efficiencies. While it is not the correct design for highest average response or for greatest simplicity, we concede that it works fairly well. The Gantt influence is seen in use of time rather than rate in the calculation. For instance, whenever an employee does better than 100% task, 160% of task time is always entered as premium time. He is, of course, only paid for 130%, as the company keeps the other half of the saving. We have then: a guaranteed day wage, a 30% step bonus at a moderate time studied task, a (50-50) constant sharing of savings above, say, point (80-130). The average earning for the plan is 137.5% of base time wages.

Differential Constant Sharing Plan.—Some time before 1917, a plan was designed in England, perhaps by Henry Atkinson,[8] which did for the sharing plan what Taylor had done for the piece rate plan. The plan as shown in Figure 55 is made up of two differently sloped sharing curves, both based on a single low but time studied task. As in the original Halsey plan, day wages are guaranteed to 62½ of what we call high task. From 62½ of high task there is a (50-50) constant sharing to 100% of high task. At that production a 10% step bonus is given; that is, 10% on base wages. This brings the task earning up to 140% of base wages. Above this (100, 140) point there is a (66⅔-33⅓) constant sharing. This latter sharing curve, when extended backward, passes through the (62½, 100) point, proving that it is based on the low task, and when extended still further, makes an intercept on the vertical axis of 33⅓%. The (50-50) constant sharing curve, when extended backward, makes an intercept on the vertical axis of 50% and is identical with the Halsey earning curve.

FORMULA FOR EARNING:

To low task	$E = 1.00\, R_h$
From 62½% to 100%	$E = .50\, H_s R_h + .5\, H_a R_h$
at 100% or high task	$E = 1.40\, H_a R_h$ (1/14 of which is bonus)
above 100%	$E = 1.06\tfrac{2}{3}\, H_s R_h + .33\tfrac{1}{3}\, H_a R_h$
(adding and subtracting)	$\underline{\quad 1.40\, H_a R_h \quad - 1.40 \quad H_s R_h}$
	$E = 1.40\, H_a R_h + 1.06\tfrac{2}{3}\,(H_s - H_a)\, R_h$

[8] H. Atkinson, *A Rational Wage System,* also G. D. H. Cole, *Payment of Wages.* Trade Union Series No. 5.

This lies above the 1.20 piece rate throughout the working range but does not have a piece rate increment as to its starting point. It is of particular interest because it illustrates the correct way to design a differential constant sharing or premium plan, both in regard to task and in regard to slopes. As will be shown later, however, we do not recommend any combination of steps and sharing lines.

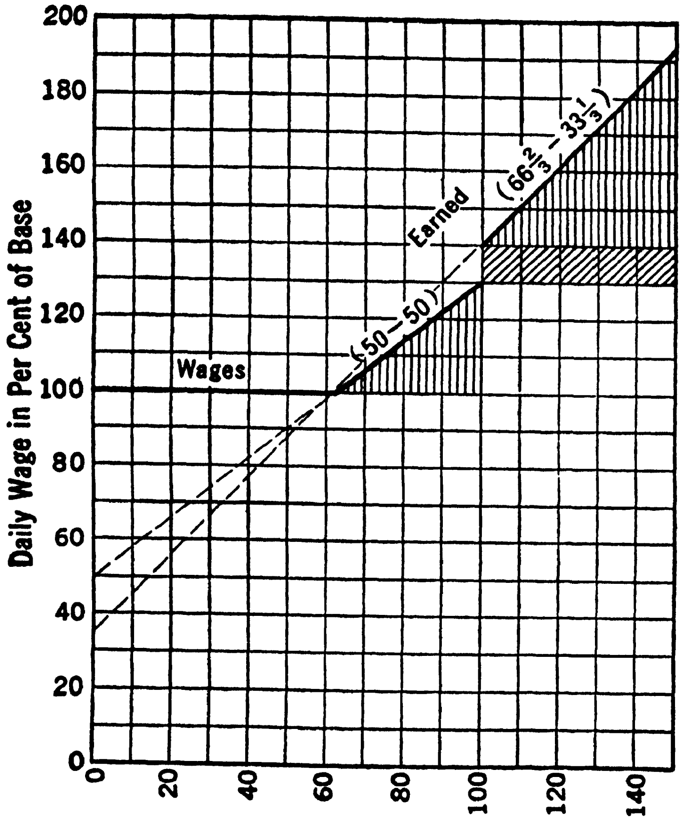


Figure 55. The Differential Constant Sharing Plan with Day Guarantee

Much less correct in principle but more like American practice, is the plan also described by Mr. Atkinson (1917) in which the 10% step of the above plan is replaced by a 5% step at 100% task and the (66⅔-33⅓) constant sharing for points above is replaced by a straight line parallel to the (50-50) constant sharing curve already mentioned. This type of plan bears the same relation to the true differential sharing plan that the Emerson type of plan above task bears to the Wennerlund plan above task. In these premium plans the extra earnings of the above task curves are figured in premium time at the same money rate. $E = .8\,H_s\,R_h + .55\,H_a\,R_h$.

Baum Differential Premium Rates.—William Baum, an industrial engineer of the Holeproof Hosiery Company of Milwaukee, in 1919 combined the Taylor step principle with the Halsey premium principle and provided from two to four steps as the conditions seemed to require. The name Baum differential gain sharing plan (Figure 56) was first applied to this by the University of Wisconsin.[9]

Plan Is Strong but Complex.—The steps in the Baum plan are certainly much stronger as incentives than the slopes between them. The very multiplicity of the steps would tend to segregate the various employees just above these steps in production. This plan has also been called the Milwaukee plan.[10] Much the same results may be obtained by the differential piece rate plan where piece rates have been used before, and by the differential time plan, where time plans have been used before. We grant that very high wages may be put into any fractional sharing, either by using step bonuses or by starting the earning curve at lower tasks, but in any case the slopes cannot keep up between production points as they do in the corresponding piece rates. The latter are decidedly more simple to figure for either the management or the men. The low slope of the premium earning curve was just the thing to give high earning for low production and to avoid high earning if any operation chanced to be incorrectly rated. This was what Mr. Halsey wanted. The premium curve met all his requirements. By its nature, however, it is unsuitable for high tasks and impractical for combination with step bonuses. The higher Baum rate curves, with the exception of one, do not have the intercept of 50% when extended back to the E axis. They are not true constant sharings but are parallel to the (50-50) constant sharing curve for point (66⅔, 100).

FORMULA FOR EARNING:

Earning up to 66% of high task = Hours Actual × Rate per Hour

$$E = H_a \quad R_h$$

Earning from 66% to 100% or high task (See Halsey Formula)

9 Industrial Relations Circular, No. 8, August 10, 1921, and again a more thoroughgoing pamphlet printed by them under the title of *Audit of Gain Sharing Plan.* It was republished in Babson's Reports and other trade publications. Mr. Baum, educated in Germany, had had discouraging experience with piece rates, and felt that the philosophy of the gain sharing idea was superior to that of piece rate. His plan was, therefore, inspired by the general philosophy surrounding plans rather than the earning curve itself. Since that time, the old trouble of rate cutting which made piece rates particularly unsatisfactory has quite generally passed. Since this is true, it is difficult to see why the constant sharing principle, which involves lower slopes than the corresponding piece rates, and is much harder to figure, should be used in connection with step bonuses. The Baum plan simply combines multiple steps with premium sloped curves and bears the same relation to the Diemer plan that the Merrick plan bears to the Taylor plan.

10 *Automotive Industries,* September, 1921. The plan seems to have spread to many factories in Wisconsin and is said to be giving satisfactory results.

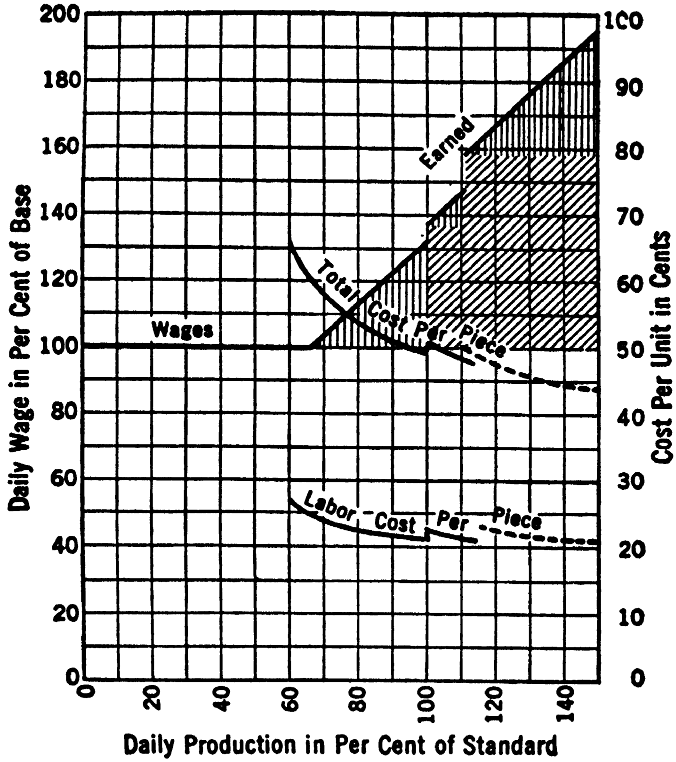


Figure 56. Baum "Differential Gain-Sharing" Plan, Three Rates

TABLE 39. BAUM "DIFFERENTIAL GAIN-SHARING" DATA, THREE RATES
(With low task at 66⅔% of high task)
6¼% step at high task and 7¾% step at 111% high task

Per Cent of Production H_s/H_a	Per Cent of Total to Base Wage for Full Day $E/H_a R_h$	Total Daily Wage in Dollars E	Number Pieces per Day	Time Saved per 8-Hr. Task in Hours $H_s - H_a$	Labor Cost per Piece in Dollars	Total Cost per Piece in Dollars
60 (96)	100	3.84	14.4	− 5.3 (− 0.33)	.27	.66
66 (107)	100	3.84	16.0	− 4.0 (0.50)	.24	.60
73 (116)	107	4.10	17.5	− 3.0 (1.25)	.23	.57
80 (128)	113	4.34	19.2	− 2.0 (1.75)	.22	.54
89 (143)	122	4.67	21.4	− 1.0 (2.375)	.22	.52
100 (160)	138	5.31	24.0	0. (3.00)	.22	.50
114 (183)	162	6.24	27.4	1.0 (3.625)	.23	.49
133 (213)	179	6.88	32.0	2.0 (4.25)	.21	.45
145 (232)	190	7.30	34.8	2.5 (4.55)	.21	.44

Earning from 100% to 111% high task,

Halsey Formula using $(R_h)_2 = 106\% \ (R_h)_1$

Earning from 111% high task on up,

Halsey Formula using $(R_h)_3 = 115\% \ (R_h)_1$

In examples: $(R_h)_1 = \$.48$, $(R_h)_2 = \$.51$, $(R_h)_3 = \$.55$

Here the time rate proceeds into the first sharing as in the regular Halsey plan. Baum's use of relative rates in the original formula is a more practical method of handling steps in a premium plan than the separate formula method used by Diemer.

Cost per Piece.—As the Baum three rate plan is the most generous of all the constant sharing plans for high productions, we may expect the average response to be as high as in the high piece rate, Taylor, Gantt, or Merrick plans. The total cost per unit will, therefore, be similarly low despite its apparent height for low production points, which will be out of range. The only question here is the cost of the clerical work, since the plan combines the multiple rate and the sharing principles.

English Bonus and Two Premium Plan.—E. D. Proud in his "Welfare Work" describes an English case (Figure 27) in which an 80% time guarantee is used to 66% of high task. From 66-100% task there is a (60-40) constant sharing. At task there is an 8% step bonus and thereafter there is a straight line earning parallel to the (60-40) sharing already mentioned. This plan might be satisfactory for former time workers but we would recommend piece rate in place of the last portion and also a higher step. The (60-40) or primary premium can also be used straight, that is, extended as a substitute for the time guarantee. This combined with higher incentives above high task would be suitable for some of our conditions today.

FORMULA FOR EARNING:

To 66% efficiency $E = .8\, H_a\, R_h$

From 66% to 100% $E = .6\, H_s\, R_h + .4\, H_a\, R_h$

At and above 100% $E = .6\, H_s\, R_h + .48\, H_a\, R_h$

CHAPTER 11

CONSTANT SHARING PLANS WITH MINUTE AS TIME UNIT

> We believe that this system if started and carried out with a policy of justice and fairness to the worker, and if his welfare is always taken into consideration, will react with the most beneficial results to the management, and will instill a spirit of cooperation in managers and men.—FRANK T. HUFFMAN, JR.

Earning Curve Not Main Feature.—Classified by the earning curves, these plans may range from low constant sharing to high piece rate. They must, however, be given separate treatment, for the use of a small time unit allows a flexibility which facilitates improved operation in two respects. First, it becomes easier to assign weights to desired variations in emphasis and to factors indirectly allied to production. This gives rise to the term "point plans." Second, it becomes easier to connect the rewards with production control. This actually makes of these plans, whole control systems. So important are these features that a high average response is possible even when the earning curve is undeniably weak in itself or the task a little less than true high task.

Bedaux Point Premium Plan.—The original "Point Premium" plan, first applied in 1919 by Charles E. Bedaux, a born salesman but no engineer,[1] guaranteed time wages up to high task and gave a constant sharing from there on (Figure 57). The sharing was usually distributed 75% to the employee and 25% to the supervisory force. The direct labor cost was, therefore, considered constant per piece, but as far as the employee was concerned, the earning increment was that of a constant sharing and less than that of piece rate. The high task location for a sharing plan was partially offset by the larger

[1] A. M. Morrini came to the United States from France about 1913 to investigate scientific management. He took back with him three Emerson engineers, George Viel, J. S. Hecox, and A. R. Decker; also one or two Taylor men, names not yet ascertained. Bedaux was employed as interpreter for this group. When the war came on Bedaux enlisted in the Foreign Legion but had returned to the United States by 1916. Being familiar with the Emerson plan he started installing practically that plan in several companies in Cleveland, particularly the White Sewing Machine Company. This was about 1919. But he wished to develop a plan of his own, and the Bedaux point plan was the result.

proportion of the share. There is not a great deal to be said for his earning curve. It has a relatively low slope and begins at too high a task location to reach even as high an earning level as either the (50-50) or the (33⅓-66⅔) constant sharing earning curves which start through the lower task. The merit of the plan lay entirely in the method of keeping track of work. The work standardized per unit of time, in this case a minute, becomes a common denominator for all performance in the company.

Definition of a "Bedaux."—This amount of work per minute, together with its proper allowance for fatigue, is called the Bedaux or "B." The B unit consists of a fraction of a minute of effort plus a fraction of a minute of compensating relaxation, always aggregating unity but varying in proportion according to the nature of the strain. In other words, it corresponds to the effort developed by an average person working under normal conditions at a normal rate of effort for one minute of time. It is set so that 60 B's constitute the task per hour, and 80 B's are considered average for select and seasoned employees. The rate of pay is likewise reduced to the minute basis, but it is easily transformed into hourly figures by dividing the number of B's by 60.

The "coefficients of rest" have always been kept secret by the Bedaux Company, but an account in French[2] does explain how such data have been computed.

Lambda λ = Coefficient of rest.

$\lambda + 1$, similar to interest calculation, is multiplied by any theoretical standard time to derive allowed time.

λ varies according to the class of operations. It has been developed by scientific studies and the data are arranged in tables.

"Dominant time," similar to the statistical mode = T_d

Allowed time probably the same as our H_s

$$(\lambda + 1)\, T_d = H_s$$

hence any actual time of work,

$$(60 - \lambda\, H_s) = H_a = \frac{60}{\lambda + 1}$$

rest allowed per B or

$$\lambda\, H_s = 60 - \frac{60}{\lambda + 1}$$

The work portion of the B is therefore $H_s\,(1 - \lambda)$ and varies according to table from $^1/_3$ to $^9/_{10}$ of the B.

[2] Paul Audibert, "General Consideration Upon the Rational Organization of Labor in Mines," Societe de Portusola.

In Reality a Production Control Plan.—Only when we look upon this plan as a production control plan rather than as a mere wage plan can we appraise it properly. In comparing it with other plans, the production control methods used with such plans should, therefore, be taken into consideration. The importance of this is that it is never applied except in intimate relation to the control. For instance, the number of B's produced by individuals or by machines is posted daily beside the number of B's standard. A foreman can at once tell which individuals are below standard and how much they are below. Similarly, a weekly or bi-weekly recapitulation sheet (Figure 59) enables each superintendent to compare the efficiencies of his foremen, and the manager to compare those of his superintendents. Comparison may even be made between the various plants of a large company, and for this reason the plan has been installed in some of the largest companies. The performance may also be given in dollars so that a manager can point out to his superintendent or foremen how much they might have saved each week if they had prevented this or done that.

Large Amount of Clerical Work a Disadvantage.—If the recapitulation sheets are carried through to include overhead costs, as they should be, the amount of clerical work necessary to operate this plan is considerable. In fact, it is likely to be five or six times as much as for most of the wage incentive plans, not including production control. It is claimed, however, that the close control, which is an inherent part of the Bedaux plan, results in an active and harmonious stimulation which gets surprising results. It is claimed that because of this stimulation in cooperation, employees may even earn as much or more under the 75% sharing arrangement as they would normally earn under the corresponding piece rate.

The very extensiveness of the plan results in a thorough-going operation of it. Certainly, no company would go into the plan at all if it were not prepared to do so in a complete way. Undoubtedly it has brought about better production control and better unity of all management controls than have some other plans. It obviates the danger of expecting too much from the wage incentive itself without proper production control. In fact, it has erred in the opposite direction.

Proportion of Clerical Work to Payroll.—A mid-west sewing machine company has operated the plan in its metal division since 1919, and in ten years applied it to 877 employees out of a total payroll of 1,202. It reports that twelve clerks on the factory side and five on the office side are required, but the management is evi-

dently satisfied that this is no disadvantage. "It gives us a very accurate measurement of the accomplishments of each individual each department and the plant as a whole, reducing all human endeavor to a common denominator. It provides an incentive for supervisors, set-up men, truckers, etc., as well as direct producers." An eastern safety razor company has operated the plan since 1922, and in seven years applied it to 996 women and 498 men out of a total payroll of 2,315 individuals. It reports 36 clerks on the factory side and 34 on the office side, but is satisfied. It cites as advantages of the plan: decreased costs; 25% to 30% increased earnings for employees; simplified control of non-productive as well as productive labor.

B Unit Brings Flexibility.—In the Bedaux plan a figure called the point hour is used to compare the efficiency of individuals and of departments. This point hour is determined by dividing the total number of points produced per department for the day by the total number of hours worked. For example, if the total number of points produced by all employees in the department per given day is 3,520 and the number of hours worked is 40, then the point hour for the department will be 88. The point hour record of an individual is posted daily and made comparable to the previous day. The employment department keeps these records as guides in the matter of promotion or rehiring. If the records were graphic, they would be hard to beat, but as they are not graphic, Gantt charts have many advantages.

Instead of planning the number of specific parts per given operation, the number of B's is planned relative to the capacity of each machine or working place. The definite jobs can be allocated within this general plan as practice requires, and readjusted without much change in paper work. The common denominator of the B permits extreme flexibility.

This same B unit is also used for cost records. To obtain standard costs, the base or hourly rates on a given operation, group of operations, or department are divided by 60, as there are 60 B's per hour in a standard performance. This, then, would give the standard cost per B. Then the B's produced divided into the money spent for direct labor gives the actual direct cost. The B's produced divided into the indirect labor gives the actual indirect labor cost. The B's produced may also be divided into the other overhead items, separately or as a group, as the particular industry or company may require.

Location of Task.—A more serious criticism of the Bedaux plan, in addition to the increase in the amount of clerical work, is that tasks are sometimes hurriedly set on past earnings by men more anxious to get the general system going than to analyze each job down to its ultimate "one best way." There is no reason, however, why this should be the case provided the management really wishes ultimate standards. Despite the claim of competing engineers that the usual Bedaux task is much lower than the Taylor-Gantt high task, in which case the Bedaux earning might be 75% of high piece rate instead of 75% of basic piece rate, we have found little of such evidence. On the contrary, we have discovered cases where former tasks have been increased 25% relative to piece work and from 33⅓% to 140% relative to day work. This is seemingly clear proof that the originators aimed to set a high, if not the ultimate, task.

One of several employers giving exact information on this question says: "It has been our experience, and that of many others with whom I have checked back, that day employees who are not working on any direct incentive plan will average all the way from a 30 to a 40 B hour as measured by the Bedaux plan, or 50% to 66⅔% of task, mostly less than 60%. When they have reached the standard of 60 B hour, at which point they first collect premium, they will have increased their production from 50% to 100%. In office work where operators have been paid on salary, we find the range from a 25 to a 35 B hour, that is, 42% to 58% of task."

Performance Under Plan.—The same employer continues: "After a group, of say 1,000 operators, is on the Bedaux plan, this group will average approximately a 70 to 75 B hour in probably about six months, but the thing that really happens in most cases is that the force is reduced due to a doubling of production per man-hour; and in getting out the same amount of production you would have less than 50% of the operators remaining, inasmuch as one would naturally keep the higher and better producers. This would immediately destroy an average condition, inasmuch as you would be taking the average of the better half of the group. This remainder should, between six months' and a year's operation, reach approximately an average of an 85 B hour. Among this group you would generally find at least five operators who would double the standards or run probably 120 B hour, and, ranging down from that point for the rest of them.[8] These high B hours would, of course, be work that is mostly hand operations and where it is possible for an

[8] These few exceptions or superworkers do not exceed 145% of a truely high task. Therefore for this case the task must have been set at about 75%. For the machine operators the task may have been around 90%. They should be alike at least!

individual to fit perfectly in the work. On a machine operation, mechanically controlled, the perfect performance would be an 80 B hour, except in cases where it is possible for the operator to operate a group of machines where there would be greater possibilities due to his extra effort. Regarding hand operations, the writer has never yet found any operation where it was not possible to find an operator, if carefully selected and trained, where old records could not be smashed."

In making comparisons of various plans, there are some intangibles impossible of measurement. Any plan where supervision, set-up men, truckers, elevator men, etc., participate in the results obtained, the production per man-hour on any given type of work or operation will be much higher than where there is an incentive for direct operators only. Hence average performance of Bedaux workers sometimes exceeds that of piece workers elsewhere.

Determination of Task.—On the labor relations issues Bedaux erred most of all. First he adopted the practice of rating, by snap judgment, each time study. Although widely used by him and copied by many others, this practice has never seemed to us justifiable. To watch an operative briefly and then to say definitely that he is a 45 B man or a 75 B man is certainly assuming a great deal. As a matter of fact, such man-rating, for it amounts to that, is quite unnecessary if the analyst is a graduate engineer with some shop experience. Any deliberate slowing down on the part of the subject is as unnatural as speeding up, never repeats exactly, and can be detected through an adequate number of recorded work cycles, if not wholly eliminated by good labor relations. Thorough working analysts have always found that such man-rating is too much guesswork and hence potentially dangerous for the purpose of "doctoring" a time study. Partly the Bedaux man-rating but particularly his resort to the "stretch-out" turned unions against Bedaux practice.[4] When textile mills began to move south for the cheaper labor cost, Bedaux made the serious mistake of hurrying his work too much. He tried to attain the efficiency of eastern mills by extending the number of machines per operator without giving them adequate training, etc. From the operative's point of view it looked like cutting the rates, and without the customary prerequisites it did amount to that. They called it the "stretch-out." On the other hand, there are many Bedaux installations which have been well done and are today running smoothly. A few, notably the B. F. Goodrich Company, have always given full labor saving instead of 75%

[4] *American Federationist*, A. F. of L., September, 1935, republished September, 1939, also newspaper publicity of November, 1937.

of it. The variation in success has seemed to depend on the management policy of particular companies and on the extent that methods improvement has been accomplished previously or is being carried on independently. In justice to the Chas. E. Bedaux Company we call attention also to their reorganization in 1937 and their present sound treatment of general maintenance. (See Chapter 18.)

FORMULA FOR EARNING:

Earning up to high task = Hours Actual × Rate per Hour

$$E = H_a \quad R_h$$

Earning up to and above task = Time Wages + ¾ Earning Saved

$$E = H_a R_h + \tfrac{3}{4}(H_s - H_a) R_h$$

$$E = \frac{R_h}{4}(H_a + 3\,H_s)$$

Key to Symbols

E = Earning in dollars (the vertical variable)
H_s = Hours standard (the horizontal variable)
H_a = Hours actual (a constant)
R_h = Rate per hour in dollars (a constant)

Cost per Piece.—The direct labor cost in the original plan may be considered constant above task as in piece rate, by including the 25% premium paid to supervisors, etc. If this latter charge is included in the burden instead, then the labor cost will be slightly lower than for basic piece rate. The total cost per piece on paper is close to that of basic piece rate either way the 25% premium is allocated. If the plan were used independently of the production control, it is quite unlikely that it would bring the average production up to the same high point usual under basic piece rate. With the operation of the whole plan, it is quite possible that average production may exceed it and thereby give a lower cost. That is, the plan should operate at a slightly lower position on the total cost curve. They are now using 100% premium in place of 75%.

Example of Bedaux Control.—As the Bedaux plan constitutes a whole production control system and a rather unique control at that, it is necessary to go into this phase more fully than for any other wage plan. The following case originally presented by Warren H. Conn of the Hood Rubber Company, Watertown, Mass.,[5] is the best description of the plan we have found. It is of interest to note that in this installation, which was started in 1920, the premium is kept separate from the base wage. The former is paid

[5] Abstracted by permission from the 1928 Year Book of the National Association of Cost Accountants, New York.

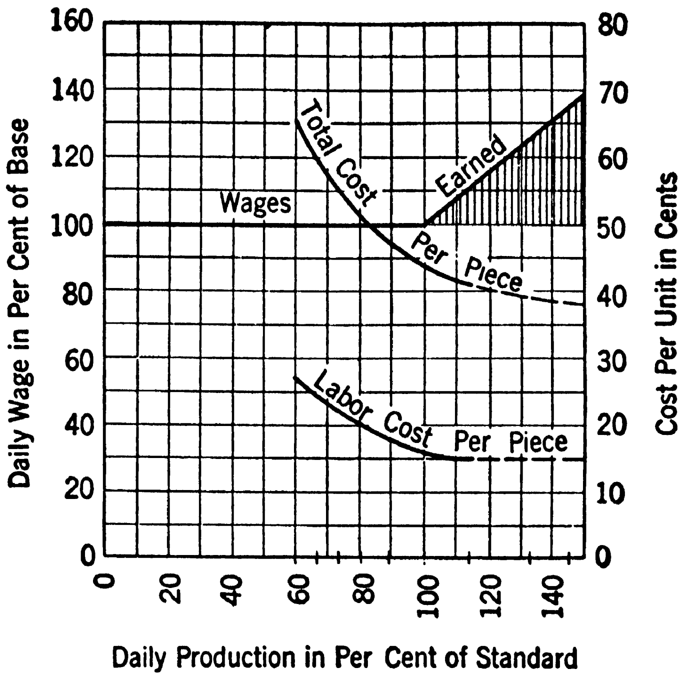


Figure 57. Original Bedaux Point Premium Plan—a (75-25) * Constant Sharing Through High Task

* The company is now installing 100% premium, see piece rate.

TABLE 40. BEDAUX "POINT PREMIUM" DATA

Per Cent of Production H_s/H_a	Per Cent of Total to Base Wage for Full Day $E/H_a R_h$	Total Daily Wage in Dollars E	Number Pieces per Day	Time Saved per 8-Hr. Task in Hours $H_s - H_a$	Labor Cost per Piece in Dollars	Total Cost per Piece in Dollars
60	100	3.84	14.4	− 5.3	.27	.66
66	100	3.84	16.0	− 4.0	.24	.60
73	100	3.84	17.5	− 3.0	.22	.56
80	100	3.84	19.2	− 2.0	.20	.52
89	100	3.84	21.4	− 1.0	.18	.48
100	100	3.84	24.0	0.	.16	.44
114	111	4.25	27.4	1.0	.16	.41
133	125	4.80	32.0	2.0	.15	.39
145	134	5.15	34.8	2.5	.15	.38

in pink envelopes and the latter in white envelopes. The beginner's rate is adjusted in proportion to the point hour efficiency, that below 60 points always is shown in red on the recapitulation sheet. When steady production is held up for any reason, an equivalent point hour is given the employee and a certain charge laid against supervision.

Study of Strain and Rest.—"Many studies were made in an endeavor to determine the relation between strain and the various degrees of energy expended for each type of motion in the performance of a job, so that ratios thus ascertained could be uniformly applied to all work done by man. Subsequently a curve was built up showing the amount of rest that is necessary to offset working times of varied length and intensity. While a minute is an inflexible measure of time, a point, measuring a minute's worth of work, may be accomplished in more or less than one actual minute. It, therefore, becomes possible to produce, let us say, 80 minutes' worth of work in an hour, or 80 points in an hour, or to make an 80 point hour. Furthermore, the point, representing the value of one minute, can be used for measuring other than regular productive accomplishment. A point can be given for each minute of idle time, breakdown, day work, supervision, or upkeep. At the end of the day an operator can have both production points and allowed points. In fact, one of the fundamental precepts of the point system is that the worker is guaranteed a point of some sort for every minute he is in the plant, from the time he checks in until the time he checks out.

Effort Measured Against Time.—"Thus the point is both a measure of human effort and a measure of time. Since the human effort element is modified by the rest and delay factor, the point becomes for all practical purposes a unit of time. A standard is the number of points allowed for the performance of an operation. Just as a point is the reasonable amount of work expected in one minute's time, so a standard of 10 points, for instance, is the reasonable amount of work to be performed in 10 minutes' time. Sixty points is the reasonable result expected from an hour's work. An operator, who by application and superior use of his capabilities, produces 80 points in an hour has exceeded required production and is credited with 20 premium points.

Development of Tasks.—"Any time study must be rated[6] according to the performance of the operator, in order that the result obtained from studying his work may be compared with the results

[6] Many companies have copied Bedaux in this superficial man-rating but we insist that it is neither necessary nor wise.

of observations of other operators and the standard performance to be set up. Under the point system this rating is very easily expressed by the hourly point accomplishment the observer judges the operator to have attained during the study. If the performance is judged to have been reasonable, the operator is rated as a 60 point operator. As the performance is judged to have exceeded the requirements of reasonable effort, the operator is rated as a 70, or 80, or 90 point operator. Figuration of the standard thus becomes simply the solution of the following equation:

$$\frac{\text{Seconds per Operation}}{\text{Seconds per Hour}} = \frac{\text{Points per Operation (Standard)}}{\text{Points per Hour (Rating)}}$$

The actual in seconds multiplied by the point rating and divided by 3,600 gives the point standard. But the standard thus ascertained represents the accomplishments possible through effort alone. Since rest and delay must be coupled with effort, this standard must be increased by the percentage of rest and delay allowable according to the nature of the operation, before the correct job standard can be set. In practice, the rest and delay allowance is added to the effort rating; the standard then computed is the complete point value of the operation.

Records of Employee Performance.—"Checking the operator's work under the point system requires 3 records. The clock sheet shows time in and out so that the total hours in the shop may be computed. The work sheet (Fig. 58) shows the operations performed, the number of units, and the standards. The allowed time sheet shows all time spent by the operator on other than standard work. As many allowed time classifications may be used as are deemed necessary to give the desired information of how non-standard time is spent. Time on and time off are recorded with the elapsed time in minutes extended under the proper classification. Day workers and all indirect workers are also carried on this sheet. Thus from these 3 sheets a complete report of everybody from the superintendent to the newest apprentice is obtained. Multiplication of the units by the standards gives the standard points earned. To these are added the allowed points, giving the total points credited to the operator for the day. Dividing the total points by the hours worked gives the point hour by which the operator is comparatively ranked with his fellow workers and his own performances on other days. Multiplication of the hours worked by 60 gives the base points which the worker is guaranteed: these subtracted from the total points give the premium points, for which an extra reward is given.

DESCRIPTION OF WORK							DIRECT							IND.		DEPT. NO.
							B's On Std.			Hrs. On D. W.						
Order Number	Sty	Part No.	Oper. No.	Part Name	Quan.	Std.	Prod.	Set	Reop.	Set	Lost	Reop.	Prod.	Sup.	Misc.	No.............Date............
																Name..............................
							D	E	JL	F	G	KM	O	PQ	R	
REMARKS					TOTALS-											B TOTAL HRS.
					B's To = Std. N		Hours On Std. C									O. T. HRS.
SIGNED					B Hour		Total B's			Prem. B's			Prem.			

Figure 58. Bedaux Operator's Production Ticket*

* This form has a carbon back and is made out in duplicate

Calculation of Earning.—"Payment of the base rate for every hour worked is guaranteed the operator no matter what his production may have been. The value of a point is found by dividing the base rate by 60. For all base points full point value is paid. For all premium points the operator receives ¾ point value. Thus the operator's weekly pay consists of 2 amounts—his base wage which is the hours worked times the base rate, and his premium which is the premium points times the premium point rate.

Daily Posting Sheet.—"A posting sheet is prepared daily for each department showing for every standard operator the hours worked, the total points credited, the point hour and the premium earned. This sheet is prominently exhibited in the room and every worker can compare himself with his fellows. The competition which the posting sheet engenders is remarkable. It is natural to have a just pride in one's achievements and when a visual record is provided the urge for superior attainment is much more decided. Furthermore, since all point hours below 60 are entered in red ink, the posting sheet serves as a powerful incentive to keep operators from going or staying below standard production. A worker quickly realizes that he has no standing with his fellow workers if he is 'in red.'

Deductions for Scrap.—"This plan of wage payment also affords simple solution of two frequently rather awkward matters. Penalties or scrap deductions can be easily and accurately made. At any stage of manufacture an article represents so many points. This amount can be used as the basis for setting up penalty standards. Scrap points are deducted from premium points. Beginners are easily identified and can be readily watched and promoted as their progress, indicated by their point hours, warrants. A beginner's base point hour is figured in the same ratio to 60 point hour as his hourly rate is to the regular hourly rate of the job. For instance, an apprentice hired at 30 cents per hour on a job with a base rate of 45 cents per hour would be on a 40 point base. A schedule is set up whereby the beginner, having attained 45 point hour for a week, is raised to 33¾ cents per hour, at 50 point hour to 37½ cents per hour, etc. Meanwhile he is paid premium whenever he exceeds his base. Thus the beginner knows just how he can increase his weekly wage. There can be no argument. As soon as his point hour shows an increase is merited, it becomes automatically effective.

Point Analysis Sheet.—"The analysis sheet is sent to each foreman as soon as possible after the week's figures have been assembled

BEDAUX

PERIOD 2 Weeks Ending 6/25/

Section 1

			DIRECT B'S						
Date	% on Std.	Total Dept. Hours	Actual Hrs. On Std.	Net Direct B's	SET UP 21131 B's	SET UP D. W.	Hrs. Lost Time	REOP. Outside B's	REOP. Outside D. W.
	A	B	C	D	E	F	G	H	I
12				+807					
13	99	493.0	435.0	35515	2367	—	—	739	0.6
14	97	516.5	454.8	39622	2384	—	—	531	1.6
15	100	508.0	457.6	39713	2381	—	—	570	0.6
16	100	517.0	461.8	40910	2421	1.0	2.5	801	0.6
17	99	520.1	457.7	39946	2676	0.5	—	502	0.6
18	99	159.0	143.7	13578	1053	0.5	—	86	0.3
19									
20	100	524.5	474.1	40979	2572	2.5	—	581	0.6
21	99	527.0	469.7	40442	2604	0.5	1.0	584	0.6
22	99	514.5	462.2	40922	2261	—	—	817	0.6
23	100	509.0	457.2	39794	2336	0.5	—	886	0.6
24	99	518.0	453.0	40958	2421	0.5	—	810	0.6
25	98	195.0	175.5	15957	1147	0.5	1.4	196	0.3
Total	99	5501.6	4902.3	429143	26623	6.5	4.9	7103	7.6

Section 2

		DIRECT PAY ROLL				
Date	Total	Total Base Rate Earnings Pay Roll	Base Rate Earnings on Std	Base Rate Earnings Not on Std.	Premium Earnings Pay Roll	Premium Reserve
	A	B	C	D	E	F
	$4251.84	249926	247427	24.99	106354	354.51

Section 3

			DIRECT LABOR			
Date	% on Std.	Total Hours Analyzed	Total B's Produced S. U. Ratio 20	Hours on Std.	B Hour	Hours Not on Std.
	A	B	D	E	F	G
	99	5509.2	443755	4922.1	90	47.3

Section 4

	COST OF DIRECT				
	Total Cost	Std. Cost Work on Std. Std. .00838	Actual Cost Work on Std.	Loss	Cost Work Not on Std.
	A	C	D	E	F
	$4251.84	3718.67	3892.32	173.65	24.99

F-182 1M 6-29

Figure 59. Bedaux

ANALYSIS

DEP'T NAME *Final Mach'g* No. *132*

& HOURS						INDIRECT HOURS				B' HOURS			
ERATIONS & REPAIRS				Hrs. to Equal Std.	Hours Not on Std.	Salary Supervision	Hourly Rate Supervision	Hdl'g Clean and Misc.	Total Hours	Oper. B. H.	Direct B. H.	Ind. B. H.	Total B. H.
Resp.		Not Resp.											
B's	D W.	B's	D. W.										
J	K	L	M	N	O	P	Q	R	S	T	U	V	W
665	—	9	—	13.3	4.0	18.0	—	36.0	54.0	89	84	71	82
191	0.3	—	0.4	14.2	14.0	18.0	—	29.0	47.0	93	90	94	90
415	—	29	—	10.2	—	18.0	—	32.4	50.4	93	90	85	89
631	—	104	—	9.8	2.0	18.0	—	31.7	49.7	95	91	88	90
408	0.3	196	1.0	13.5	3.0	18.0	—	39.6	57.6	94	91	76	89
—	—	—	—	0.9	1.3	9.0	—	4.5	13.5	102	98	109	100
241	—	—	—	10.6	1.4	18.0	—	28.5	46.5	92	89	95	89
239	0.2	—	—	16.0	7.1	18.0	—	30.5	48.5	92	89	91	89
483	—	134	—	10.9	4.7	18.0	—	29.6	47.6	95	91	93	91
731	—	—	—	6.3	—	18.0	—	33.3	51.3	94	89	83	89
522	—	112	2.0	7.2	2.8	18.0	—	41.7	59.7	97	93	75	91
—	—	—	—	6.6	3.6	9.0	—	5.0	14.0	97	93	126	95
4526	0.8	584	3.4	119.5	43.9	198.0	—	341.8	539.8	94			

INDIRECT PAY ROLL											
Est. Monthly Sup. .80	Gen. Factory Labor Pay Roll	Misc. Pay Roll	P. O. Pay Roll	Total	Avg. Base Rate Earnings Direct	Avg. Base Rate Earnings Indirect	Std. Exp. Material Scrap / Std	Actual Exp. Mat. Scrap	Labor Effectiveness	Ind. Prem. B's Per hr.	Departmental Effectiveness
G	H	I	J	K	L	M	N	O	O-	P	Q
158.40	176.13			334.53	.504	.515				26	86

INDIRECT LABOR				TOTAL DIRECT & INDIRECT LABOR				
Std. Allow. B's Ratio 9.6	Hours on Std.	B Hour	Hours Not on Std.	Total B's	Hours on Std.	B Hour	Hours Not on Std	Waste and Losses Hours
H	I	J	K	L	M	N	O	P
46224	534.4	86	5.4	489979	5456.5	90	52.7	424.9

COST OF INDIRECT				COST OF TOTAL DIRECT & INDIRECT				
Std. Cost Work on Std. Std. .00080	Actual Cost Work on Std.	Loss	Cost Work Not on Std.	Std Cost Work on Std	Actual Cost Work on Std	% Excess Over Std.	Cost Work Not on Std.	Waste and Losses
G	H	I	J	K	L	M	N	O
355.00	331.18	23.82	3.35	4073.67	4223.50	4	28.34	178.21

Analysis

and computed. By referring to the supervision point hour shown and then tracing variations back through the cost percentages to the totals used and thence to the posting sheet and daily allowed time sheets, a foreman can find out exactly what occasioned the conditions indicated and take steps to encourage or prevent their recurrence. All this should be done with any plan but here it is a part of the plan itself and hence never omitted. (See Figure 59.) The analysis sheet shows:

1. The number of operators, direct and indirect.

2. The number of operators below standard, or 'in red' for the week.

3. The total hours, direct, indirect and standard.

4. The total direct points and subdivisions showing standard points, day work points, experimental points, assignment allowance points, guarantee points and all other excess direct allowance points as may have been provided for by the allowed time classification.

5. The total indirect points and subdivisions showing points paid for supervision, clerkship, inspection, handling, etc., as classified on the allowed time sheet.

6. The equal standard points or those points given to operators as base points for which no production was received.

7. The total direct payroll and subdivisions showing the amount paid for each of the direct point accounts.

8. The total indirect payroll and subdivisions showing the amount paid for each of the indirect point accounts.

9. The amount paid for equal standard points, split between that chargeable to training apprentices and that chargeable to supervision for failure to bring beginners along according to schedule or allowing 60 point operators to slip back 'into red.' This split charge on beginners is arrived at by setting up a progress schedule for every operation showing the point hours experience has indicated and can be attained each week of the training period. If an apprentice makes the schedule no charge is made against the foreman. Any equal standard points due to difference between point hour attained and base rate point hour is considered a normal training expense. If an apprentice fails to make the schedule, the cost of the equal standard points occasioned by the difference between his actual point hour and the scheduled point hour is charged against supervision.

10. The total controllable labor, or the labor costs which the foreman has it in his power to control. This would include all indirect costs, the excess direct costs of idle time, breakdown, reoperation, etc., and the equal standard cost as mentioned above.

Various Uses of the Point Hour.—"From the above figures are computed:

1. The operator's point hour, which is the standard points divided by the standard hours.

2. The departmental point hour, which is the standard points plus all allowances at 60 not charged against supervision divided by the total direct hours; thus all points paid for idle time, breakdown, reoperation, etc., are a total loss to supervision.

3. A point hour adjustment for beginners, which is the difference between 60 and the average base point hour of all standard operators, beginners being figured at their scheduled point hour.

4. The premium point basis, which is the departmental point hour plus the point hour adjustment minus 60.

5. The standard cost per point, which is the cost of standard labor divided by the standard points.

6. The indirect cost per point, which is the total indirect payroll divided by the standard points.

7. The controllable cost per point, which is the total controllable labor cost divided by the standard points.

Planning.—"Production schedules can be accurately set up and easily controlled. By means of the standards, all goods to be produced, of whatever kind or variety, are converted into points. By using point hours as a gauge, the number of operators or machines, the number of man-hours or machine-hours necessary to get out the assigned production is known. By means of this comparable medium, supervision can ascertain the amount of work to be done and the amount of labor and equipment necessary to do it. Inversely, by being in possession of the knowledge of the productive capacity of his operators, a foreman is in a position to know how much production he can handle. Planning for increases in production weeks ahead is possible by use of the beginners' schedules, by means of which the number of apprentices and the time for hiring them can be definitely forecast. Normal progress of new operators being predetermined, provision can be readily made for all additional work. In retrospect, the extent and cost of all labor turnover is at hand. Coincident with planning for standard operators, use of the indirect standard, broken down into its component parts, will permit laying out a program for changing the amount of indirect labor in proper proportion to production changes. Thus a foreman can guard against disastrous fluctuation in his cost efficiency percentage.

Indirect Production.—"The premium point value for indirect workers is 1/60 of the weekly salary. Multiplying this value by the premium points earned in the period gives the premium amount. For ease in computation the premium is usually figured as the same percentage of the wages paid for the period as the average weekly premium points is of 60. As in the case of standard operators, in paying-off, premium is given out separately. Statistics for computing this indirect premium are gathered from the posting sheet, the allowed time sheets and the payroll sheet and entered each week on a control sheet known as the point analysis sheet, which is laid out to show figures for 13 weeks. Each quarter of the year is divided into 3 periods—2 four-week periods and a five-week period. Indirect premium is paid once each period.[7]

Derivation of Standard Cost per Point.—"A standard controllable cost per point is set up for each factory section. Time studies are taken and ratings made on all indirect operators, from which ratios are determined between each kind of indirect labor and the standard points available. By dividing this factor, increased to a weekly basis, into the weekly rate for that class of indirect labor, a standard cost per point for each type and a total indirect standard cost per point are obtained. Allowances for unpreventable excess direct labor may be included if desirable. The resulting total is the standard controllable cost per point. The cost efficiency is then figured by dividing the standard controllable cost per point by the actual controllable cost per point. This efficiency percentage is applied to the premium point basis and the resulting figure is the supervision premium points earned for the week.

Use of Cost Data.—"For aid in quickly noting cost conditions, the percentage of day work, allowance, equal standard, indirect, and total costs to standard cost is shown. By multiplying the standard by the standard cost per point, the standard cost of the operation is obtained. The total points on an article, so costed, give the total standard cost. Many operations, ordinarily classed as non-productive and figured on a percentage basis, by means of point standards can be definitely charged at their true relative weight. Due to the fact that standard operators are paid premium at 75% of the point value, the actual cost per point varies. As an accounting expedient, cost estimates are made at standard point value. Indirect premium costs can then be charged against this excess, any balance being credited to the section. The analysis sheet shows, in the various excess, direct and indirect costs per point, the actual charges in each factory section for

[7] Application of the Bedaux plan to maintenance is described in Chapter 18.

the different kinds of other than standard labor. Thus representative data are furnished for determining such additions to the standard cost as are necessary, and comparisons between the costs set up and the actual costs can be readily made. By considering each department or section according to the total standard points produced therein, an exact means of proportionately allocating various general items of burden expense is at hand. Knowing the relation between the point production on each article and the total section points, a further breakdown can be definitely made.

Results at Time of Installation.—"As an immediate result we had the satisfaction of realizing a substantial saving in labor costs, and, at the same time, of increasing the average earnings of the operators. Only a part of this improvement can be exclusively credited to the point system. The benefits derived from a complete, thorough, entirely new time study survey of all operations, and a factory-wide house cleaning of all the old piece rates and hourly rates, hoary with tradition, would doubtless have been approximately the same regardless of the new system installed. It should be noted, however, that the point system, by its very nature, compels such a wholesale research. Furthermore, the very great incentive given the direct operators by the system is largely responsible for the results attained.

Continuing Results.—"First, we have a single all-inclusive term for expressing all phases of labor. We plan in points, record production in points, reward the effort and efficiency of both direct and indirect operators through points, compare workers, sections and departments by means of point hour, and summarize manufacturing conditions in points.

"Secondly, we have an incentive plan of wage payment tying in all operators who aid in carrying our product through to completion, no matter from what angle. Due to the absolute separation between standards of performance and money paid, each can be guaranteed in its own field and necessary changes made in the one without affecting the other.

"Lastly, in the analysis sheet, management has a most useful tool, for ascertaining along what lines man-power and machine-power have been spent and the money value of this expenditure. Excess costs are its responsibility. With these costs the analysis sheet mainly deals. Thus the senior executive, knowing the variations from standards, can make every effort to permanently eliminate the causes. It is physically impossible for the factory manager or department superintendent to personally see what is going on. With the analysis sheet on his desk he gets the picture.

DIRECT B's PRODUCED BY IND. OPERATORS						
DATE	OPER. NO.	DIRECT B'S	OPER. NO.	DIRECT B'S	OPER. NO.	DIRECT B'S
TOTAL						

DISTRIBUTION OF NET DIRECT B's														
DATE	TOTAL													
	B'S	D.W.	B'S	D.W.	B'S	D.W.	B'S	D.W.	B'S	D.W.	B'S	D.W.	B'S	D.W.
TOTAL														
PAY ROLL														

COMPUTATION OF INDIRECT PREMIUM					
NO.	NAME	HOURS	PREM. B'S PER HR.	VALUE PER B	TOTAL PREM.
					TOTAL

Figure 60. Bedaux Analysis (*reverse side*)

"Points tell the operator where he stands, supervision where it stands, and management how the whole labor structure stands. Through this medium all parties can work together with mutual understanding and confidence. The point system has been introduced into industry by its originator in response to the need which has been felt for a system of measurement of the value of the human effort."

The sample forms (Figures 59 to 61) are furnished by the company already cited.

The Bedaux Analysis of Operation Sheet is divided into four sections which are numbered at the left (Figure 59).

Explaining Figure 60, the reverse side of Bedaux Analysis, Figure 59:

Direct B's produced by Indirect Operators: All direct B's produced by any indirect operator are recorded in this space.

Distribution of Net B's: Where necessary, production is distributed to various account numbers for accounting purposes.

Computation of Indirect Premium: Distribution of Premium Payroll of the Indirect Operators.

Section 1. Daily B's and Hours. Computed and analyzed daily from individual operator's production ticket, Figure 58.

Section 2. Payroll. Computed every two weeks from payroll distribution and totals of Section 1, Daily B's and Hours.

Section 3. Analysis of Labor—B's and Hours. Computed every two weeks from totals of Section 1, Daily B's and Hours.

Section 4. Analysis of Cost. Computed every two weeks from totals of Section 2—Payroll, and Section 3—Analysis of Labor—etc.

The Bedaux Summary Analysis of Operation Sheet is divided into two sections which are numbered at the left (Figure 61).

Sections 5 and 6. Summary of Analysis of Labor—B's and Hours—and Summary of Analysis of Cost. Posted every two weeks from Sections 1, 2, 3, and 4 excepting columns 6B and 6P which columns are computed every two weeks.

At the end of a quarter, all columns are totaled, excepting columns 5A, 5F, 5J, 5N, 5Q, 6B and 6P which are computed.

To obtain the results by divisions, the respective departments making up the respective divisions are totaled and computed from Sections 5 and 6 and posted on to another sheet of Sections 5 and 6 for that division every two weeks.

BEDAUX

PERIOD Quarter Ending 6/30

Section 5

				DIRECT LABOR			
Date	% on Std.	Total Dept. Hrs.	Net Direct B's	B's Produced S.U.R. 20	Hrs. on Std.	B Hr.	Hrs Not on Std.
	A	B	C	D	E	F	G
4/2	98	4798.2	359559	374157	4215.0	89	78.3
4/16	99	4697.9	353439	364656	4119.6	89	58.9
4/30	98	4225.8	310533	318702	3725.1	86	61.6
5/14	99	4916.4	371443	382330	4363.4	88	41.6
5/28	99	4969.4	370079	382934	4436.0	86	32.1
6/11	99	4752.9	356112	367792	4219.7	87	44.4
6/25	99	5501.6	429143	443755	4922.1	90	47.3
Total	99	33862.2	2550308	2634326	30000.9	88	364.2

Section 6

			COST OF DIRECT			
Date	Total Cost	Direct Cost per B Std. .00880	Std Cost Work on Std Std. .00838	Actual Cost Work on Std.	Loss	Cost Work Not on Std.
	A	B	C	D	E	F
4/2	$3662.25	.00929	3135.44	3297.38	161.94	42.82
4/16	3592.65	.00925	3055.82	3249.44	193.62	20.92
4/30	3141.62	.00920	2670.72	2819.05	148.33	37.74
5/14	3714.40	.00913	3203.93	3368.89	164.96	21.89
5/28	3712.31	.00918	3208.99	3374.90	165.91	22.21
6/11	3555.09	.00910	3082.10	3221.49	139.39	21.17
6/25	4251.84	.00913	3718.67	3892.32	173.65	24.99
Total	$25630.16	.00918	22075.67	23223.47	1147.80	191.74

Figure 61. Bedaux

SUMMARY ANALYSIS

DEPT. NAME Final Machining NO. 132

INDIRECT LABOR				TOTAL INDIRECT LABOR					
Std. Allow B's R 9.6	Hrs. on Std.	B Hr.	Hrs. Not on Std.	Total B's	Hrs. on Std.	B Hr.	Hrs. Not on Std.	Waste and Losses	Departmental Effectiveness
H	I	J	K	L	M	N	O	P	Q
38975	501.6	78	10.2	413132	4716.6	88	88.5	415.0	84
37985	520.5	73	5.3	402641	4640.1	87	64.2	437.9	82
33198	436.8	76	8.9	351900	4161.9	85	70.5	371.1	80
39826	512.2	78	5.2	422156	48756	87	46.8	436.1	83
39889	504.2	79	5.1	422823	4940.2	86	37.2	436.5	82
38312	490.4	78	5.0	406104	4710.1	86	49.4	392.6	82
46224	534.4	86	5.4	489979	5456.5	90	52.7	424.9	86
274409	350a1	78	45.1	2908735	335010	87	409.3	2914.1	83

COST OF INDIRECT				COST OF TOTAL DIRECT AND INDIRECT					
Std. Cost Work on Std. Std .00080	Actual Cost Work on Std	Loss	Cost Work Not on Std	Std Work on Std.	Actual Cost Work on Std.	% Excess	Cost Work Not on Std.	Waste and Losses	Total Cost per B Std. .00944
G	H	I	J	K	L	M	N	O	P
297.33	315.61	16.28	6.44	343477	3612.99	5	49.26	182.36	.01019
291.72	319.07	27.35	322	3347.54	356851	7	24.14	224.81	.01016
254.96	279.13	24.17	5.70	2925.68	3098.18	6	43.44	176.46	.01011
305.86	320.38	14.52	324	350979	368927	5	25.13	18308	.01000
306.35	312.05	5.70	3.15	3515.34	3686.95	5	25.36	176.41	.01003
294.23	309.31	15.08	3.12	3376.33	353080	5	24.29	154.47	.00998
35500	331.18	23.82	3.35	407367	422350	4	28.34	178.21	.00991
210745	218673	103.10	2822	2418312	2540.20	5	21896	127580	.01005

Summary Analysis

Haynes Manit Premium Plan.—In 1924, Hasbrouck H. Haynes published the first description of his point plan. For unstandardized industries where the task level was low and uneven, a one-half sharing was paid the employee and one-tenth of the sharing was paid to those concerned with supervision. The remaining four-tenths of the saving was retained by the company. For standardized industries a five-sixth sharing went to employees and one-sixth to supervision. The simplified formula for the direct producer's earning was, therefore:

$$E = (5\,H_s + H_a)\,\frac{R_h}{6}$$

This was very close to the Bedaux plan, not only in its use of the minute as a unit but also in the earning premium.

Improved Plan.—On January 1, 1928, the Haynes Corporation changed its plan to pay full labor saving to the direct producers, thus adopting basic piece rate but based on a minute unit of time.[8] This is a fairer proposition for the employee and is simpler to figure. Supervision and indirect labor are rewarded 4½% of the combined earnings of the direct laborers who produce individually at a daily rate exceeding 60 "Manits" per hour, but this must come from overhead saved and not from labor saving, as formerly. This removes the weak feature of the former plan and should hold the average response higher than under the Bedaux plan. No analysis is needed as the earning formula, chart and direct labor costs are identical with those of the basic piece rate plan already analyzed.

Parkhurst Differential "Bonus."—Frederick A. Parkhurst, a one time assistant of Bedaux, developed in 1903 a point plan to which he applied the term "differential." As he used a step at 60% of high task, the term differential would naturally be taken to mean this abrupt differentiation in earning, but since he makes a further differentiation in having ten classes of work and a schedule of incentives for each class (Table 42), it is possible that he meant the term to apply to this latter differentiation. The incentive is more often started at 70%, although tables begin at 60%. The classification is based on the difficulties and responsibilities of the various jobs, not directly referring to the men who may do the jobs. The jobs would also be classified by their base rates as under all other plans. Each class scale is designed to give a differentiation of $.25 per day incentive for task production, and the class number indicates the number of these $.25 differences. For instance, class number 2

[8] *Manufacturing Industries,* Vol. XVII, No. 2, and *Management,* Vol. XXXII, No. 5.

carries an incentive of $.50 a day at task, and class number 5 an incentive of $1.25 a day for task.

The first claim made for this rather elaborate classification is flexibility, that is, a greater percentage of employee time can be put on incentive basis than by using any single scale. Parkhurst states[9] that both direct and indirect labor may be reached by the plan to the extent of 65% of total payroll hours, in some cases 90%, and that the average industrial plant would ordinarily have from 75% to 80% operating on the plan.

Plan Well Worked Out in Advance.—The classification is carefully established by the higher management, and guaranteed, so that there is no opportunity to juggle with the classes. The bonuses and premiums are figured in advance, and while they depend upon the efficiency of production, they are entirely independent of any employee's time rate. The differential is based on a ratio of one to two in production; for a ratio of incentive compensation, 1 to 10. For instance, at 50% task the incentive pay is 1/10 of what it is at task. It is evident that no such comprehensive and fixed plan could be operated without careful time study. Not only are individual performances constantly recorded in per cent of standard, but departmental efficiencies may also be computed as frequently as once a week if desired. With these figures it is possible to pay an incentive to indirect laborers and supervisors, going as high as general supervisors. The plan, therefore, has a definite connection with production control, which undoubtedly makes it more effective than plans which are not so connected.

Schedule of Promotion.—One advantage of this thorough classification is that a definite schedule of promotion is always in sight of employees and management. We have said that the incentive was independent of the base rate, but it is evident that a man who is given a very low base rate is incompetent to do a job designated in one of the higher classifications. If a man can qualify permanently for work in a class higher than the one for which he was hired, his rate would be altered to the range usual to that classification. In slack times, when it becomes necessary to assign a lower class to an employee than usual, the management does not pay an incentive in per cent of his base wage, but it pays the lower incentive provided for that class. The employee retains his regular rate, and loses only in the difference of incentive of the two classes. In short, the incentive schedules are maintained regardless of busy or slow times, although class assignments and base rates may change.

[9] *Manufacturing Industries,* Vol. XIV, Nos. 4-6.

Clerical Work Involved.—Mr. Parkhurst claims that there is no additional work required for this plan over that required for any adequate payroll. The elaborateness of the system gives the impression that clerical work is excessive, but it should be remembered that the very elaborateness of the tables means that a great deal is figured in advance and needs only to be looked up in tables for payroll computation. As in all point plans, it is not fair to compare the clerical work with that for other plans unless the clerical work for production control is included. Timekeepers are supplied with slide rules so that they may quickly compare standard hours with actual hours. The resulting efficiency is quickly looked up in the table and the total wage easily computed. Mr. Parkhurst uses the minute as a time base rather than the hour. The cost department uses the incentive chart in figuring standard costs.

Emphasis on the Individual Rather Than the Group.—Mr. Parkhurst believes that employees should be treated as individuals wherever possible, and that they should be advised daily of the amount of their incentive earnings. At the end of the pay period, the total incentive is given to the employee in an envelope separate from his regular pay envelope.

Plan Applied to Groups.—As in any plan using standard time, it is comparatively simple to total the standard hours formed by a group and divide this by the total actual hours. The efficiency of the whole group is looked up in the tables and may be easily differentiated for different classes of work if the nature of the work requires men of more than one class. In the accompanying chart (Figure 62) the area between the broken lines represents the possible range of earning between the lowest class, number 1, and the highest class, number 10. This is not the true position for the limiting classes, because each class is intended for a different range of time rates also, which would narrow the earning range on a percentage chart. Class number 2 is used for examples, as it corresponds most nearly to the base rate of 48 cents an hour used throughout this book. While the amount of the step bonus is not great except for the higher classes, and while the slopes of the curves would be less than those of the corresponding piece rates, the plan is so well supported by the production control features that it undoubtedly elicits fairly good average response and through the indirect incentive may even assist the employee to keep constantly at work and thereby secure a higher earning than under more generous earning curves lacking such support.

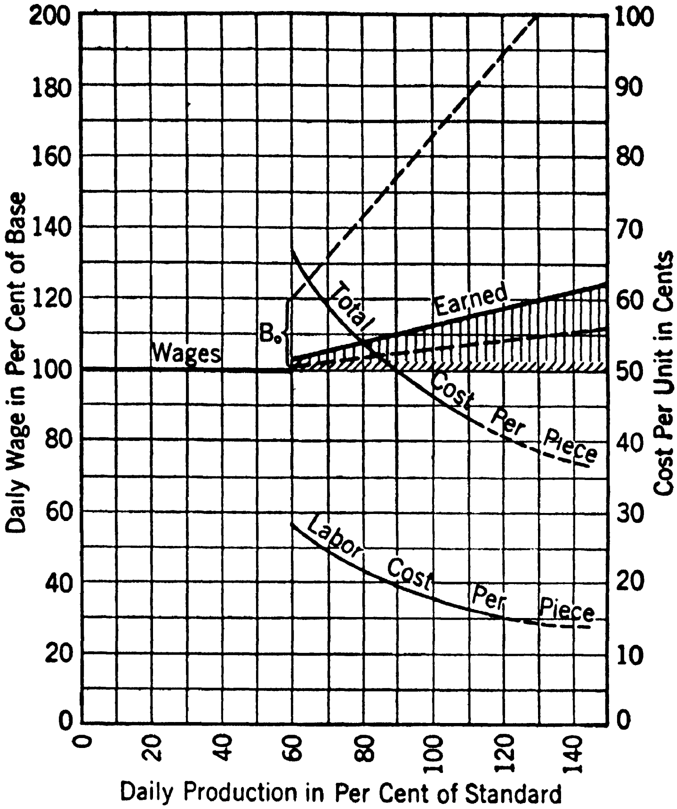


Figure 62. Parkhurst Differential Incentive Plan, Class 2

TABLE 41. PARKHURST DIFFERENTIAL INCENTIVE DATA—CLASS NO. 2

Data taken from official Parkhurst table and combined with $3.84 Day Wages

Per Cent of Production H_s/H_a	Per Cent of Total to Base Wage for Full Day $E/H_a R_h$	Total Daily Wage in Dollars E	Number Pieces per Day	Time Saved per 8-Hr. Task in Hours $H_s - H_a$	Labor Cost per Piece in Dollars	Total Cost per Piece in Dollars
60	103	3.98	14.4	− 5.3	.28	.67
66	105	4.03	16.0	− 4.0	.25	.61
73	107	4.10	17.5	− 3.0	.23	.57
80	108	4.16	19.2	− 2.0	.22	.54
89	110	4.24	21.4	− 1.0	.20	.50
100	113	4.34	24.0	0.	.18	.46
114	116	4.46	27.4	1.0	.16	.42
133	120*	4.59	32.0	2.0	.14	.38
145	123*	4.71	34.8	2.5	.14	.37

* Last two rows of figures extrapolated.

Weakness of the Plan.—The greatest fault of the plan is the low position of the step bonus. On the positive side it seems foolish for an employer to pay abruptly a larger amount of wages unless it is accompanied by sufficiently high production, to lower overhead costs materially. On the negative side, it is likely to make a certain number of employees content to produce barely above the production point where the step is located, and certainly the step location is unfortunate for that. It is also difficult to see how such a low slope earning curve can ever satisfy employees who have been on piece rate. In connection with this point, it is understood that Mr. Parkhurst has given full piece rate occasionally for productions from 100% of task and above. When this is done the plan becomes one of the most generous of all plans to the employee.

FORMULA FOR EARNING:

Earning up to 60% high task = Time Wages

$$E = H_a R_h \tag{1}$$

Earning from 60% high task and above = Time Wages + Certain % Time Wages

$$E = H_a R_h + I \quad H_a R_h$$

$$E = (1 + I) H_a R_h \tag{2}$$

Although the incentives are fixed independently of the time wages, they can be reduced to formula. For instance, for class number 2 where incentive is \$.05 at .50 H_s, and \$.50 at 1.00 H_s, based on a \$4 day wage scale,

Slope formula origin at (0, .8875) $m = \dfrac{y_2 - y_1}{x_2 - x_1}$

$$m = \frac{.125 - .0125}{.555 - .055} = .225$$

Straight line formula $y = m \quad x + b$

$$\frac{E}{H_a R_h} = .225 \frac{H_s}{H_a} + .8875$$

$$\text{or} \quad E = \left(.225 \frac{H_s}{H_a} + .8875\right) H_a R_h \tag{3}$$

$$E = .225 H_s R_h + .8875 H_a R_h \tag{4}$$

Adding and subtracting .1125 $H_a R_h$, the incentive can be isolated from day wages,

$$E = (.225\, H_s R_h - .1125\, H_a R_h) + H_a R_h$$

$$E = \left(H_s - \frac{H_a}{2}\right) .225\, R_h \qquad + H_a R_h \tag{5}$$

$$\therefore \quad I = \left(H_s - \frac{H_a}{2}\right) .225\, R_h \text{ Class No. 2 only} \tag{6}$$

As I values in the table are figured on the typical rate of \$.50 per hour (for class number 2) and the curve here given uses those with a \$.48 per hour rate, there is a slight discrepancy between the book illustrations and any examples coming from the E formula.

If all ten classes of incentives should be applied to a single base time rate of, say, \$.50 per hour, or \$4 per day, a general formula for all classes of the Parkhurst plan could be derived.

Write formula (6)

$$I = \left(H_s - \frac{H_a}{2}\right) m\, R_h \qquad \begin{cases} \text{for all classes of bonus} \\ \text{but on a single day rate of} \\ \text{\$4} \end{cases}$$

in which m is a constant for each class and derived by the slope formula as already illustrated. For the ten values of m, see Table 42.

TABLE 42. PARKHURST BASE RATES FOR INCENTIVE CLASSES

	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8	Class 9	Class 10
Differential in %........	.0009	.0019	.0028	.0038	.0047	.0056	.0066	.0075	.0084	.0094
Typical Rate per hr. in dollars................	.45	.50	.55	.60	.65	.70	.75	.80	.85	.90
Value of m in % for a single day rate of \$4.00...	.1125	.225	.3375	.45	.5625	.675	.7875	.90	1.0125	1.125

Substituting this general value of I in formula (2),

$$E = \left[1 + \left(H_s - \frac{H_a}{2}\right) m\, R_h\right] H_a R_h \tag{7}$$

A still further simplification comes from using $m =$ class number multiplied by 1125. It must be remembered, however, that these values of m only apply to the single \$4 day rate so that for a range of day rates they would have to be figured separately as illustrated by class number 2.

Cost per Piece.—The costs under the Parkhurst plan are apparently low. It should be remembered, however, that the slope of the

BONUS CHART AND INSTRUCTION CARD

Note—All Time is Expressed in Minutes and Decimals

CUSTOMER: *G. & B. Mfg. Co.*

ARTICLE OR JOB: *CRANK HANDLE PIN—T-55—T-65*

SYMBOL: *K4671X*

OPERATION: *Form .403" Dia., spot drill, turn 15/32" Dia., form head and cut off*

INCENTIVE CHART *23486*
DATE *March 31st 19–*
DEPARTMENT *145D*

Quantity	Material	Work Point Symbol	Drawing Symbol	Preparation Time	Standard Time
10,000	¾" C. R. S.	P. & W. #14511	K4671X	None	4.12

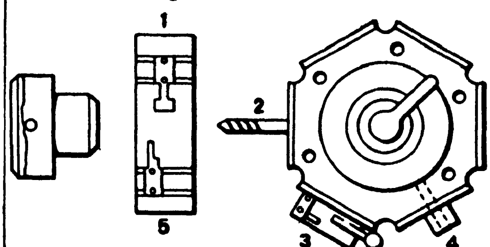
THE FOLLOWING INSTRUCTION MUST BE STRICTLY FOLLOWED

Method One Operator—Bonus Class #6	
RT—Bar to stop	.20
PO—TO	.07
Form .403" Dia. 11/16" shoulder, 456-RPM., Hand Feed	.35
RT—PO—TO	.07
Spot drill with 5/16" Drill point, 456-RPM., Hand Feed	.07
RT—Bar to stop	.20
PO—TO	.12
Turn 15/32" Dia. 5" shoulder, Clutch High, Belt High, Lever Left and Back Gears in, Fine Feed, 456-RPM	1.65
RT—PO turret with guide bushing	.12
PO—TO	.03
Form 3/8 R. and cut off, 456-RPM., Fine Feed	.54
Net time	3.44
Allowance added 19.8%	.68
Standard time per piece Man Min.	4.12

Equipment

Tool Equipment:
1—P. & W. Turret Lathe, #14511

1—Forming tool—H. S. S.
1—Cut off and forming tool—H. S. S.
1—Turning tool
1—5/16" Drill for center pointing
1—Guide bushing



No Bonus Will be Paid Except for First-Class Workmanship

INCENTIVE CHART

NOTE—The following prices will be paid as Incentive in addition to hourly wages based on GOOD PIECES which pass inspection, after this specific operation, EXCEPT that DEFECTIVE not due to work specified on this chart will not be deducted in paying incentive. These Incentive Prices WILL NOT BE LOWERED, no matter how long the job may run with this equipment and by the method and design specified in the instruction referred to.

INCENTIVE

				Good Pieces 8.7 Hrs.	Paid Class 6 8.7 Hrs.				
				88.6	$ .69				
				94.9	.82				
				101.2	.96				
				107.6	1.09				
				113.9	1.23				
				120.2	1.36				
				126.6	1.50				
8.7 Hr.	Std. =	$\frac{522}{4.12}$ =	126.6 Pcs.						

IF WORK CANNOT BE DONE AS SPECIFIED SEE *R Riege*, Time Study Chief	Customer *G. & B. Mfg. Co.* Piece Symbol *K4671X* Operation *Form .403" Dia. spot drill, turn 15/32" dia., form head and cut off*	Standard Time (Min.) *4.12* Differential ($) *.02131* Incentive Chart *23486* Issued by *Nelson*

Figure 63. Sample Incentive Chart and Instruction Card

earning curve is not steep and has no point of emphasis at task. The response is likely to be scattered and will not average as high as under a steeper earning slope. Furthermore, incentives are paid for supervision and should be considered in the matter of costs. Perhaps in practice this incentive may actually result in maintaining a fairly high average response, in which case the cost location is moved to the right, where it is lower and may well justify the indirect incentive. In Mr. Parkhurst's own articles he shows curves for costs below the 60% production point. While it may be desirable to show earning curves below this point, it seems unthinkable that average production would ever be allowed to remain below that point. Total costs have only to do with this average production.

Example of Parkhurst Bonus Plan.—An eastern company manufacturing machinery for nineteen years has applied this plan to 1,000 men. This includes 82% of direct labor and 70% of indirect labor. Very thorough time studies are used for establishing the tasks and individual production records are kept. There has been a 125% increase in production and a 50% decrease in "direct labor and burden cost per unit." At the same time, average wages have increased considerably. Fourteen men are required to operate the plan on the factory side which includes time study. Five clerks are required on the office side which includes timekeeping and payroll work. The plan provides for promotion and salary scheduling. It also assists in budgeting. The average man efficiency is 96%. The sample incentive chart and instruction card is self-explanatory (Figure 63).

Other "Unit" Plans.—The Dyer plan[10] includes a machine rate in the computation for earning of machine operators. The machine rate is expressed as a fraction such as 65/60ths for a drill press The formula for earning becomes:

$$E = H_a R_h + \frac{4}{5} (H_s - H_a) R_h R_m$$

or in terms of minutes instead of hours,

$$E = \frac{M_a R_h}{60} + \frac{4}{5} \frac{(M_s - M_a) R_h R_m}{60}$$

this may be reduced to,

$$E = \frac{R_h}{60} \left[M_a + \frac{4}{5} (M_s - M_a) R_m \right]$$

10 See *The Iron Age*, Vol. 127, No. 21.

which means that the minutes actual are added to four-fifths of the minutes saved times the machine rate and all multiplied by the man rate per minute. The average response is said to be at about 118% efficiency.

Key to Additional Symbols

M_a = Minutes actual = 60 H_a
M_s = Minutes standard = 60 H_s
R_m = Machine rate in per cent

Lesser known plans of this type are the K. I. M.[11] plan developed by du Pont engineers and the Norm plan developed by Keyes-Weaver consulting engineers. The latter uses piece rates and provides foreman bonuses based on controllable costs. The Shanley and the Stevens plans are similarly offshoots of Haynes and Bedaux.

Weighted Points Applied to Sales.—Sales work is being compensated with the same idea of measurement, but without regard to any specific earning curve. The plan recognizes the circumstance that duties other than immediate selling are important. These various factors are weighted according to their worth and a net score is provided for each salesman. New accounts, follow-up, demonstrations, supervision of installations, trials, daily calls on owners, prompt reports, and many other things leading to special profits are given their proportionate rating relative to sales. The plan gives the sales manager any control he wishes, and the only disadvantage is that a little more advance planning and extra clerical routine is required. Such control is particularly desirable where the superior is not in close touch with his men. Much the same thing is accomplished under the name of salary, commission, and premium. The weighted points may be subdivided to provide for premiums on: special features, net profits, total sales, quota excess, low sales cost, service to house, increased efficiency, promotional work, and branch-office sales.

Point System for Sales.[12]—Since the quantity or volume is not always in proportion to the sales effort, the point system is particularly helpful in this field. The number of calls made by the salesman or the number of new orders may be the best measure of his effort. In fact, the problem is so varied that it must be worked out specially for each given case. "The point system involves the use of a common denominator. The sale of the product requiring the least resistance is usually that denominator. A point is given for every dollar

[11] Initials of King, Irvin, and MacLachan.
[12] Bulletin of The Taylor Society, Vol. VI, No. 4.

of that one product sold, and upon that standard all other values are determined.

"Penalties are fixed for not doing the things the company wants done.

"The value of a point having been determined, the salesman's salary, figured in points, will indicate what he had to do in tasks to justify his pay. If $.008 is the value of a point, 5,000 points would be necessary to get $40.00 a week. The following factors are used in giving points:

	Points Credit	Points Debit
1. CREDIT FOR SELLING DESIRABLE PRODUCT:		
Basis of reward one point per dollar sale.		
(a) Easy selling advertised product	1	
(b) Products offering double net profit	2	
(c) Products offering triple net profit	3	
(d) Products especially hard to sell	2	
(e) Products that have very high repeat qualities	2	
(f) Products that are being closed out	2	
2. CREDIT FOR SECURING PARTICULARLY DESIRABLE BUSINESS:		
(a) New customer who discounts bills	200	
(b) New customer who pays within thirty days	150	
(c) New customer who takes sixty days or over	100	
Half credit when order is received by mail.		
One-quarter credit when order is closed by office.		
Penalty for loss of customer—"six months without buying"		150
3. CREDIT FOR COOPERATING WITH CREDIT DEPARTMENT:		
(a) Information which results in saving account	100	
(b) Local investigation of new account	50	
(c) Valuable information regarding old account	50	
Penalty for bad debt through failure to report		100
Penalty for bad debt not due to salesmen		50
4. CREDIT FOR COOPERATING WITH ADVERTISING DEPARTMENT:		
(a) Report on dealer advertising activities	2	
(b) Getting dealer to use store advertising matter	10	
(c) Getting dealer to use dealer electrotype	10	
(d) Securing mailing list from dealer	10	
5. CREDIT FOR COOPERATING WITH SALES DEPARTMENT:		
(a) For every report turned in	1	
(b) For calls made without sales	2	
(c) Information of interest to other departments	1	
6. PENALTIES AND REWARDS FOR QUALITY OF SALESMANSHIP:		
(a) Misrepresenting facts		1,000
(b) Complaints from customers		500
(c) Goods returned "in addition to credit"		100
(d) Falling off in sales over last year		100

CHAPTER 12

VARIABLE SHARING PLANS

> In works in which the production is of a kind that makes accurate time setting difficult, or in works which have no records to work upon, or which desire to establish a premium system rapidly, the Rowan System is miles better than other payment by results systems.—Sir W. Rowan Thomson.

Rowan Variable Sharing Plan.—James Rowan of the David Rowan and Co., Glasgow, Scotland,[1] devised in 1898 a sharing plan (Figure 64) in which a variable or algebraic fraction was used for sharing rather than the arithmetic fraction used by Halsey. The fraction consists of the ratio hours saved divided by the hours standard. The resulting earning curve starts at the low task of 62½% production, rising sharply and then decreasing gradually until a point of 200% base wages is reached, at which place the earning curve becomes asymptotic to the 200% wage line. From this it will be seen that it is impossible under this plan for any employee ever to earn twice his base time wages.

This rather ingenious means of protecting the employer was deliberately contrived by Mr. Rowan and makes his plan advantageous to the employer where tasks are taken merely from production records, or otherwise set, without time study. The early rise in the earning curve gives a marked advantage to the employee over the Halsey plan for low productions, but above 90% of high task the increase is less rapid and above 125% of high task the earning gets less than under the Halsey plan. Excepting for this slight difference, all that has been said under the Halsey plan applies to the Rowan plan. Furthermore, this plan is more complex to figure and is less likely to hold average production to a high point. In the book already cited, the author points out that the maximum point of the earning curve may be located wherever desired. The plan has been mostly used in England, where it is looked upon as a means of avoiding rate cutting. There is little to be said for it in this country, where both higher productions and higher earnings are common practice and

[1] *A Premium System of Remunerating Labour,* Proceedings Mechanical Engineers, British, 1901. Also Transactions A. S. M. E., Vol. 25, 1903. Also Wm. Rowan Thomson, *The Premium Bonus System,* 1919.

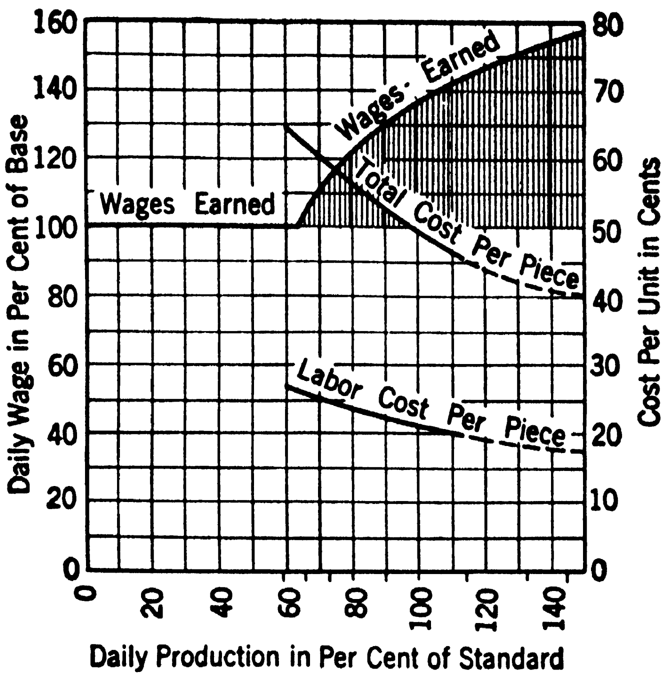


Figure 64. Rowan Variable Sharing Plan

TABLE 43. ROWAN VARIABLE SHARING DATA

Per Cent of Production H_s/H_a	Per Cent of Total to Base Wage for Full Day $E/H_a R_h$	Total Daily Wage in Dollars E	Number Pieces per Day	Time Saved per 8-Hr. Task in Hours $H_s - H_a$	Labor Cost per Piece in Dollars	Total Cost per Piece in Dollars
60 (96)	100	3.84	14.4	− 5.3 (− 0.33)	.27	.66
66 (107)	106	4.09	16.0	− 4.0 (0.50)	.26	.62
73 (116)	114	4.36	17.5	− 3.0 (1.125)	.25	.59
80 (128)	122	4.68	19.2	− 2.0 (1.75)	.24	.56
89 (143)	131	5.02	21.4	− 1.0 (2.375)	.23	.53
100 (160)	137	5.28	24.0	0. (3.00)	.22	.50
114 (183)	145	5.58	27.4	1.0 (3.625)	.20	.46
133 (213)	154	5.90	32.0	2.0 (4.25)	.18	.42
145 (232)	156	6.04	34.8	2.5 (4.55)	.18	.41

where rate cutting has largely disappeared.[2] For application of the Rowan plan to indirect production, see Chapter 18.

Formula for Earning:

Earning up to low task = Hours Actual × Rate per Hour

$$E = H_a \quad R_h$$

Earning at and above low task = Time Wages + Per Cent of Hours Saved × Time Wages

$$E = H_a R_h + \frac{(H_s - H_a)}{H_s} \quad H_a R_h = H_a R_h \left[2 - \frac{H_a}{H_s} \right]$$

in the form

$$y = m \quad x + b$$

$$\frac{E}{H_a R_h} = \left[\frac{2 H_a H_s - H_a^2}{H_s^2} \right] \frac{H_s}{H_a} + 0$$

As H_a approaches zero, the sharing fraction approaches unity, so that the maximum earning is equal to $2 H_a R_h$. Of course, such a limit is merely academic because even small values of H_a are beyond realization. A more general form includes a constant F:

$$E = H_a R_h \frac{F H_a R_h (H_s - H_a)}{F H_a + H_s - H_a} = H_a R_h \left[\frac{H_s - H_a + F H_s}{H_s - H_a + F H_a} \right]$$

Westinghouse has used this with $F = 1$, $R_h = 1.12$, and calls it the Mansfield plan.

In the Bayle form:[3]

$$E = H_a R_h + 2 H_a R_h \left[\frac{H_s - H_a}{H_s} \right]^2$$

Key to Symbols

E = Earning in dollars (the vertical variable)
H_s = Hours standard (the horizontal variable)
H_a = Hours actual (a constant)
R_h = Rate per hour in dollars (a constant)

Cost per Piece.—The total costs of the Rowan plan are a little higher than those under the Halsey (50-50) constant sharing plan for the production points involved. It is, in fact, the most expensive plan we have analyzed. This condition reverses itself for high productions, but the average response would not be on this part of the earning curve.

[2] It has been used for special conditions by the General Electric Co., Westinghouse E. & M. Co., Edison Elect. Appliance Co., and the Miehle Printing Paper Mfg. Co., in some cases on a high task.

[3] *American Machinist,* Vol. 72, No. 8.

Example of Rowan Plan.—The following case is taken verbatim from Sir Wm. Rowan Thomson's book.[4]

Regulations.—"Memorandum of Arrangement made by David Rowan and Co., with their Engine Shop Workmen, on 2nd February, 1898, the day on which the men returned to work after the Strike of 1897–1898:

1. The time allowed for any job will be fixed by the management, and will be, as near as can be ascertained, the time which should be taken to the job, when working on time.
2. The time allowed will include all the time necessary to procure tools, set up machine, and obtain material for doing the job.
3. For calculating the premium, the time taken on a job will include all working hours between the starting time of the job and the starting time of the next job.
4. A time allowance, after it has been established, will only be changed if the method or means of manufacture are changed.
5. The hourly rate of wages will, in all cases, be paid for the hours worked. If a man takes longer to do a job than the time allowed, this will in no way affect the premium which he may have made or may make on any other job.
6. Overtime, nightshift, and other allowances will be paid to the men on the same conditions as already prevail.
7. If an article turns out defective while being machined and is condemned, due to a flaw in the material, the workman will receive no premium on that article (of course, he gets his time wages), but if he has several articles on the one 'line,' and one of them is condemned, due to a flaw in the material, he will still get the premium, if earned, on the rest of the articles.
8. If a man's workmanship, when finished, does not pass inspection, he will receive no premium for that article, unless he can make the work good within the time allowed, in which case he will still receive any premium earned.
9. In cases of dispute, the matter will be referred to the management, whose decision shall be final.
10. Each workman after starting a job will receive a 'Job Ticket' or 'line' on which he will find a description of his job, the time when started, and the time allowed. When the job is finished, he will return his 'line' to his foreman, who, if satisfied with the work, will initial and write on it the time when finished, which will be the starting time of the man's next job.

[4] *The Rowan Premium Bonus System of Payment by Results,* 2nd ed., with consent of publisher, McCorquodale and Co., Ltd., Glasgow.

11. In the case of a job requiring the services of a squad of men, a time allowance will be fixed for the complete job. If the total time taken by the squad is less than the time allowed, a premium will be paid to each man in the squad. This premium will have the same relation to his time wages for the job as the time saved by the squad will have to the time allowed.

12. Fitting-shop apprentices in their first year are considered boys and one-third of the time they spend on a job will be calculated against it for premium. The percentage thus found will be paid on the whole time which they spend on a job. Those in their second and third years will be considered junior apprentices, and one-half of the time they spend on a job will be calculated against it for premium. The percentage thus found will be paid on the whole time which they spend on the job. Fitting-shop apprentices in their fourth and fifth years will be considered senior apprentices, and three-quarters of the time spent by them on a job will be calculated against it for premium. The percentage thus found will be paid on the whole time which they spend on the job.

13. Apprentices at machines will be allowed 25 per cent more time on a job than a journeyman.

Classification of Apprentice Jobs.—"In dealing with the fitter apprentices, it will be observed from paragraph 12 above that these are graded into three classes—'boys,' 'junior apprentices,' and 'senior apprentices,' and, instead of varying the time allowances to suit each of these grades, the Times Taken by them are modified for premium computation.

"For example, a certain job has for its standard time allowance 16 hours, to which a boy takes, say, 24 hours. One-third of this, or 8 hours, is taken as the basis for calculating his premium—he is, in fact, supposed to have done the job in 8 hours—in which case his percentage of time saved would be—

$$\frac{\text{Time Allowed} - \text{Supposed Time Taken}}{\text{Time Allowed}} = \frac{16 \text{ hours} - 8 \text{ hours}}{16 \text{ hours}} = 50\%$$

"That is, he would be paid 50% premium on the 24 hours he actually took, and the amount of his premium will be $= .5 \times 24$ hours $= 12$ hours.

"A junior apprentice on the same 16 hours' job does it in, say, 20 hours. One-half of this, or 10 hours, is the basis for calculating his premium. The rate of premium in this case will be—

$$\frac{\underset{16 \text{ hours}}{\text{Time Allowed,}} - \underset{10 \text{ hours}}{\text{Supposed Time Taken,}}}{\text{Time Allowed, 16 hours}} = \frac{16 - 10}{16} = \frac{6}{16} = 37.5\%$$

and he would be paid 37.5% on 20 hours, the time he actually took. The amount of his premium will be $= .375 \times 20$ hours $= 7\frac{1}{2}$ hours.

"A senior apprentice on the same 16 hours' job does it in, say, 16 hours. Three-fourths of this, or 12 hours, is the basis for calculating his premium.

"The rate of premium will be

$$\frac{16 \text{ hours} - 12 \text{ hours}}{16} = \frac{4}{16} = 25\%.$$

The amount of his premium will be $= .25 \times 16$ hours $= 4$ hours.

"Each of these apprentices is, of course, always paid for the whole time he spends on the job, and the premium hours are added to his time, the total multiplied by his hourly rate being his wages for the job.

"The reason for employing this method is the necessity of maintaining a common standard time throughout for journeymen and apprentices alike. This permits of the time allowed being always the same, irrespective of the proportions of journeymen and/or each grade of apprentice who may be employed on the job.

Job Instructions.—"As regards the operations themselves, it will be obvious to everyone that these should be as detailed and as clearly defined as possible. One of the most important duties of the rate fixing department will be the compilation of accurate and reliable data in a suitable shape, which cannot be obtained if time allowances are set to contain more than one clearly defined operation. For example, the total time taken to all the operations required for the complete machining of, say, a connecting rod, is in itself of no great value, but to be of the greatest use should be broken up so as to show the individual Times Taken by the various men and/or machines engaged on the various detailed operations, such as time for turning, times for the different slotting operations, time for boring, and so on.

"Operations should be reduced to their elementary form, and individual 'lines' or 'job tickets' given for each. Dealt with in this way, not only will the recorded data be of some real value, but much better results will be obtained all round.

"Data quickly accumulate, and once a fair amount has been obtained, tabulation should be given some attention. A data book is kept with tables of standard times for repetition work such as drilling holes, tapping holes, inserting studs, machining flanges, etc.

"On the right hand are set down, as they arise, the results of the boring out of various sizes, etc., these being entered up from the completed 'job tickets' or 'lines.' The left hand is a table of standard

time allowances and Times Taken, which is compiled from the average results shown in the record of performances.

Interpolation of Time Allowances.—"It is a convenient plan to classify all main engine pieces by grading these in accordance with crankshaft diameter, and giving a distinguishing numeral for each standard size of engine. Take propeller shaft liners. One would put the bore of the liners advancing by inches down the left hand side, and the length advancing by feet along the top. Then, having filled in all the times allowed and taken for liners previously done, it becomes an easy matter by interpolation to select a time allowance for any intermediate size. There are some machines, doing a fairly regular class of work, which lend themselves to an easy start, and whenever a reasonable amount of data has been obtained, the system can be initiated. The foreman informs the rate fixer that 'John Smith's' next job will be the turning complete of a set of three connecting rods, giving him the contract number of the job. From this the rate fixer, who has beside him a set of blue print drawings of the job in question, gets the particular size of the job and its crankshaft diameter, or standard number. On reference to the data book he gets the standard time allowance. This and other necessary particulars he enters upon a 'job ticket' or 'premium line.' The counterfoils of these lines are kept in the time office or rate fixing department.

Recording Elapsed Time.—"As soon as possible after the job is started, the rate fixer hands this line to the foreman, who, having satisfied himself that the description of the work to be done is correct, passes it on to John Smith. The latter usually has previous information which allows him to make any arrangements he wishes in the way of preparation for this job, when he comes to start it, and he almost always does this while his previous job is in hand. When John Smith has finished with the job, he hands his line back to his foreman, who, having satisfied himself that the job is right, puts the date and hour of finishing on the line and initials it. The line is then returned to the time office, and completed, by marking on it the actual number of hours during which John Smith was at work on the job as shown by the time books. This may be quite different from the actual number of hours made up from the dates of starting and finishing shown on the line, owing to John Smith working late, losing time in the morning, or other similar reasons. The actual time worked is then compared with the time allowed, and the premium earned is calculated. This is quite a simple mechanical operation on the slide rule which anyone can be taught in a few minutes. The premium hours are then entered on the premium line.

"It is to be carefully noted that this date of finishing is the starting date which is put on the new line for John Smith's next job. By this provision, there is no standing time between jobs, and for this reason the time allowance always covers this. The premium hours are entered from the premium line into the wages book. This is done for each job which the workman completes during the pay week. These premium hours earned during the week are then added up and extended at the same rate as the workman's ordinary time.

Interruption of Jobs.—"While it is desirable to finish an operation once started, this is not always possible, but when a job has to be stopped, the line is marked 'off job' by the foreman, who writes on it the date and time of stopping, and hands the line into the time office, and gets a new line for the new job. When the old job is resumed, the same line which was stopped is re-issued from the time office with the date of restarting marked on it.

"The interrupting job is, of course, very properly debited with all the time which elapses between the date at which the workman started to dismantle his old job, and the date at which the old job was back again at the machine and the workman ready to resume the operation at the exact stage where he left it off. This time has, therefore, to be accounted for in some way, and is naturally charged against the cause of its origin. Theoretically, the standard time allowance for the interrupted job should be increased by an allowance for the extra time involved in dismantling and resetting the old job, which extra time would not have arisen but for the interruption. When cases such as these occur, which is very seldom in any shop not engaged in repair work, previous arrangements can usually be made to reduce the extra time involved to a negligible quantity, and no allowance is made. But where the time involved assumes appreciable dimensions, a separate line is issued for the dismantling and resetting, which is treated as a separate job.

Group Basis.—"Job tickets or 'lines' for a squad are much the same as those for individuals. It is not necessary that the different men on the line start or stop at the same date, but the starting and stopping dates of each man must be carefully noted—this may be written on the back of the line. If it is a big job, with a large squad of men, it is necessary to use a book for this purpose. The line issued to the squad in such a case contains only a note of the job and the time allowance.

Rate Setting.—"The first thing a firm ought to do is to appoint a rate fixer. Rate fixing is a duty which should on no account be put

into the hands of the foremen themselves—they have, or ought to have, quite enough to do in their ordinary course of duty without having this additional work thrust upon them. The clerical work itself is sufficiently great to make it highly undesirable thus to waste any foreman's time in dealing with it, and for various obvious reasons it is better that the work involved in compiling and analyzing data and settling time allowances should be in the hands of an official in a more or less judicial position.

"The rate fixer should, therefore, be as good a man as possible, for in the course of time, as the system grows and spreads to other departments, he will naturally have to organize his own to keep pace with the requirements, and will ultimately become a very responsible official. He should, therefore, command and merit the respect of the entire management and the workmen themselves, and should possess a large share of tact and discretion. He must, of course, be a trained engineer, with as intimate a knowledge of shop conditions and practice as possible. He will, in any case, soon acquire this, if he is wise enough to walk warily at first. In course of time, he will require one or more assistants, who should be tradesmen with a good knowledge of drawings, a fair education, and character and ability to gain the respect and confidence of the workmen. There are many such amongst the workmen themselves, and the rate fixing department will form a most useful training and recruiting ground for assistant foremen.

"The rate fixing department, being in such intimate connection with the foremen and timekeepers, will make it their business to carry these along with them, by consulting and collaborating with them when occasion requires. In all likelihood, the rate fixing and time keeping departments will ultimately merge into one.

Operation of Plan.—"No firm need be deterred by the apparent additional cost to their standing charges, which the creation of this new department may involve. If it and the system are efficiently organized, and properly and sympathetically worked, the trouble and extra expenditure will be amply repaid by the results obtained, and by the finer spirit and atmosphere created throughout the whole establishment.

"But, at the outset, it must not be left to run or create itself. One of the principals of the firm must make it his business to take a keen and daily interest in what is being proposed and done. If he is convinced of the merits of the system, he will allow no difficulty to stand in the way, and will see to it that the system is honestly and impartially administered—every complaint investigated and put right

at once—and any departure from a rigid adherence to the fundamental principles of the system visited with prompt and adequate punishment.

"His object should be to deserve, win, and retain the confidence and esteem of his workpeople in his honest administration of the system; and, until the time arrives when time setting may have to be done by a highly trained independent expert, jointly appointed and paid by the employers and the workmen, nothing should be allowed to stand in the way of attaining this."[5]

Barth Variable Sharing Plan.—Carl G. Barth,[6] an associate of Taylor, conceived the idea of designing a wage plan which would have an earning curve similar to the Rowan plan, but extending all the way to the origin (Figure 65). He took wage elements and combined them in a way that would give a horizontal parabola. In short, he multiplied hours standard by hours actual and took the square root of the product, multiplying the result by the rate per hour. This substitutes the geometric mean for the arithmetic mean used by Halsey.

The earning curve rises rapidly through low production and approaches the straight line for higher production with less slope than the Halsey constant sharing line. It avoids the time guarantee and passes through the low task point, so that even for high production it gives a fair earning. The fact that it is one of the few earning curves to pass through the area between time rate and piece rate below task, makes it distinctly suitable for employee beginners.

Mr. Barth indicates that it is meant for "shops that still have no scientific rating, or such merely in a crude way, which is still all that the majority of shops have. It may also parallel satisfactory piece rates for jobs on which constant practice makes a worker so expert that no kind of time study as now practiced can set a satisfactory rate to use for a worker who has reached only a moderate degree of expertness, or who is entirely new at the job. If any shop has such a defective system of time allowances that jobs can be performed in one-fourth the time allowed by an honest worker, doubling his day wages should not be begrudged him."

Although difficult to explain to employees, actually the formula is quite simple. If a table is made out for earnings, very little clerical assistance is needed. As it is particularly adaptable to the period of learning, it is recommended that it be used up to low task and then followed by one of the other plans for higher production. We cannot

[5] For American case see N. A. C. A. Bulletin, April 15, 1930.
[6] *Management and Administration*, Vol. VIII, No. 1, and Bulletin of Taylor Society, Vol. XIV, No. 5.

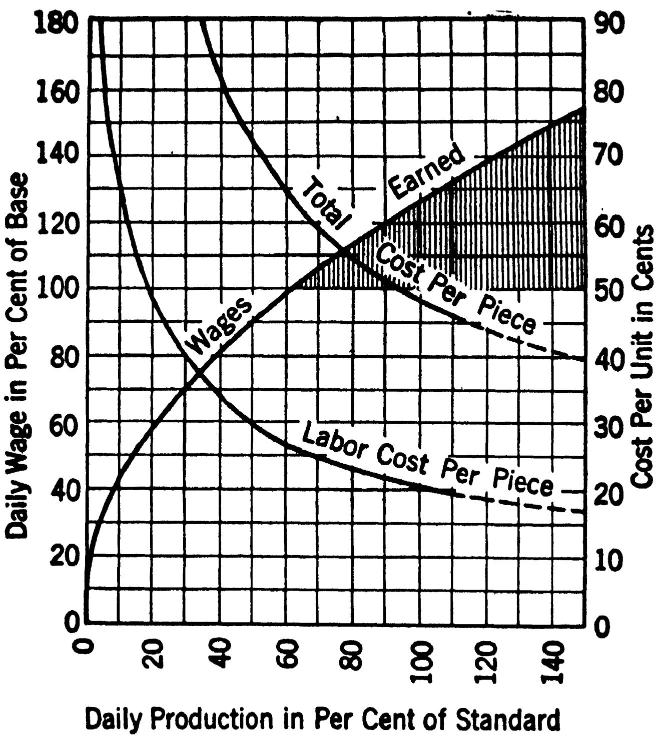


Figure 65. Barth Variable Sharing Plan

TABLE 44. BARTH VARIABLE SHARING DATA

Per Cent of Production H_s/H_a	Per Cent of Total to Base Wage for Full Day $E/H_a R_h$	Total Daily Wage in Dollars E	Number Pieces per Day	Time Saved per 8-Hr. Task in Hours $H_s - H_a$	Labor Cost per Piece in Dollars	Total Cost per Piece in Dollars
0 0	fictitious	0	0	fictitious	0*	3.84*
10 (16)	.40	1.54	2.4	− 72.0 (− 42.0)	.64	2.36
20 (32)	.57	2.18	4.8	− 32.0 (− 17.0)	.45	1.37
30 (48)	.69	2.66	7.2	− 18.6 (− 8.7)	.37	1.02
40 (64)	.80	3.07	9.6	− 12.0 (− 4.5)	.32	.84
50 (80)	.89	3.44	12.0	− 8.0 (− 2.0)	.28	.72
60 (96)	.98	3.76	14.4	− 5.3 (− 0.33)	.26	.65
66 (107)	1.04	3.98	16.0	− 4.0 (0.50)	.25	.61
73 (116)	1.08	4.16	17.5	− 3.0 (1.25)	.24	.58
80 (128)	1.13	4.35	19.2	− 2.0 (1.75)	.23	.55
89 (143)	1.20	4.61	21.4	− 1.0 (2.375)	.21	.51
100 (160)	1.26	4.86	24.0	0. (3.00)	.20	.48
114 (183)	1.34	5.14	27.4	1.0 (3.625)	.19	.45
133 (213)	1.42	5.59	32.0	2.0 (4.25)	.18	.42
145 (232)	1.52	5.84	34.8	2.5 (4.55)	.17	.40

* Not per piece.

stress too highly that it is one of the best plans which we have encountered for employee beginners, because it gives neither time wages, which are unearned, nor piece rates, which are discouraging at low efficiencies. For relocation to high task, see Figure 16.

FORMULA FOR EARNING:

$$\text{Earning} = \begin{matrix}\text{Square}\\ \text{Root of}\end{matrix} \left(\begin{matrix}\text{Hours}\\ \text{Standard}\end{matrix} \times \begin{matrix}\text{Hours}\\ \text{Actual}\end{matrix} \right) \times \begin{matrix}\text{Rate}\\ \text{per Hour}\end{matrix}$$

$$E = \sqrt{H_s \quad H_a} \qquad R_h \tag{1}$$

Dividing by $H_a\ R_h$,

$$\frac{E}{H_a\ R_h} = \sqrt{\frac{H_s}{H_a}} \quad \text{or} \quad y = \sqrt{x} \quad \text{and} \quad y^2 = ax \tag{2}$$

$$\text{where } a = \text{unity}$$

Note that when $H_a = H_s$, the formula can become either $H_a\ R_h$ time wages, or $H_s\ R_h$ piece wages.

Cost per Piece.—Costs for the Barth plan are particularly low for low productions. For higher productions, the costs decrease a little more rapidly than under basic piece rate, provided such higher productions are reached on the average. As we recommend the plan only for low productions we can say that it is one of the lowest total cost per unit plans.

CHAPTER 13

EMPIRIC PLANS WITHOUT STEP BONUSES

> Between the extremes of vague and unrelated profit sharing and the one sided exploitation of piece rates, many recent methods have been evolved for paying variable wages for varying efficiencies.—HARRINGTON EMERSON.

Emerson Efficiency-Bonus.—Harrington Emerson,[1] who gained his early experience on a western railroad and in mining camps on the Yukon, in 1904 became a consultant for the Santa Fe Railroad. The employees of this road were on a strike and the management wished to improve the entire labor program. Mr. Emerson sought to avoid the difficulties of piece rate by setting up an empiric[2] scale of earnings to be paid according to a corresponding scale of efficiencies. At first, these efficiencies were figured over a monthly period. Mr. Emerson always claimed that it is fairer to average an efficiency for a month, or at least a week, so that the shortcomings of a single day will not be discouraging to the employee. This cushioning feature sacrifices the "immediacy" feature.

Mr. Emerson used time study, but in a way that many schedules were set up from a few studies. Instead of providing a large single incentive at high task, as in the case of the Gantt plan, Mr. Emerson preferred to spread the incentive between points of production which correspond approximately to the low task and high task points. Starting with the guarantee of time wages, he therefore established a series of small "bonuses" from 67% of high task up to high task (Table 45). These are the only empiric points in his plan. From there on, he established, in terms of hours actual and hours standard, a straight line earning curve parallel to, and higher than basic piece rate. The empiric part of the Emerson earning curve is nearly the arc of a circle on the scales here used, culminating in a 20% bonus at high task (Figure 66). This avoids any pronounced demarcation at a task point. Mr. Emerson conceded that emphasis of the task as in the Gantt plan is logical but thought it severe in philosophy and preferred not to put such stress upon the task location.

1 Harrington Emerson, *Efficiency*, also *Industrial Management*, 1920.
2 In earlier writings we have used the word arbitrary, but we believe the word empiric is not so likely to imply the use of high-handed methods. In engineering the word empiric is well accepted for experimental figures.

Not a Piece Rate Above Task.—In his writings Mr. Emerson repeatedly pointed out that, under this plan, the employee receives full pay at his hourly rate for all the time he saves. He claimed the employee is ethically entitled to all this saving, and anything given above full saving is gratuitous and likely to infringe on the rights

TABLE 45. EMERSON EFFICIENCY-BONUS SCALE

Efficiency in % of High Task	Bonus in % of Base Wage	Efficiency in % of High Task	Bonus in % of Base Wage
67	.01	85	6.17
68	.04	86	6.84
69	.11	87	7.56
70	.22	88	8.32
71	.37	89	9.11
72	.55	90	9.91
73	.76	91	10.74
74	1.02	92	11.62
75	1.31	93	12.56
76	1.64	94	13.52
77	1.99	95	14.53
78	2.38	96	15.57
79	2.80	97	16.62
80	3.27	98	17.70
81	3.78	99	18.81
82	4.33	100	20.00
83	4.92	Increments of 1% thereafter	Increments of 1% thereafter
84	5.53		$B_o + P_r = I$

For piece rate from the last point, the increments would need to be 1.20% bonus per 1% production. For Sylvester Scale see *Manufacturing Industries*, Vol. XI, No. 4.

of the management. The plan in itself is peculiar in that it carries out this ideal in one sense but not in another. Relative to the basic piece rate earning, the curve of which passes through the (100, 100) point, the Emerson plan does give the employee all the saving plus a constant 20% bonus, but since the earning curve is at 120% on the wage scale while at 100% on the production scale, the Emerson plan should carry on this ideal relative to that point rather than relative to the (100, 100) point. This it does not do. Despite the two rewards contained in the formula, the slope of the curve above high task is that of the basic piece rate earning curve only, and therefore less than that of the piece rate curve passing through the (100, 120) point.

From the earning at task, therefore, the Emerson plan does not proceed according to the ideal stated by Mr. Emerson. Only by comparing with a lower point on the chart can his plan be harmonized with the ideal. No doubt this is all he meant to do, but his interpretation has been misconstrued to mean more than a piece rate

slope. The difference will readily be seen by comparing the Emerson earning curve with the Gantt earning curve.[3] Both begin at the same earning point for high task, that is, 120% base wages. The present Gantt curve has the true piece rate slope for its starting point and would lead to the origin if extended. The Emerson curve, while parallel and above the basic piece rate, does not have the true piece rate slope for its starting point, and will be seen to have an intercept of 20% on the earning axis when extended. The mathematics of this curve is most interesting and does much to explain the inconsistency just outlined. In fact, it may seem strange, but it is nevertheless true, that an earning curve which starts at a point above that of basic piece rate must have a greater slope than basic piece rate in order to give proportional increment in earning for the increments in production.

Advantages Claimed by its Originator.—The following claims are taken verbatim from the writings of Mr. Emerson:

1. The plan is easy and attractive for beginners.
2. The bonus to beginners is so slight as not to be a burden, yet is an evidence of good faith.
3. The plan is easily combined with part hourly times.
4. A man is measured and rewarded, not by the separate job, but by all work over a period. His efficiency is determined by dividing the sum of the standard time by the sum of the actual times.
5. The plan can be applied to a group of men working at different rates and for different times.
6. Above standard it pays a man his full regular hourly rate for all the time saved and pays in addition 20% bonus above wages for the time worked. See B_0 in tables.

Referring to these advantages, we wonder what Mr. Emerson meant when he wrote regarding advantage number 2 that the bonus "is at first so slight as not to be a burden." An incentive reward is not usually considered a burden upon the receiver and should not be so considered upon the giver, because the specified production must always precede the payment of the incentive. There is a good deal to be said for an earning curve which is concave upward, provided it is not too localized.[4] The real fault we find with the Emerson plan is that from high task onward, the earning curve fails to increase as rapidly as the piece rate for the point of its start. Advantage

[3] The Emerson earning above task is exactly what Gantt first used and then discarded for the (100, 120) piece rate.

[4] See Chapter 15, Accelerating Premiums.

number 5 is by no means peculiar to the Emerson plan. In fact, almost any of the simpler plans can be applied readily to groups as well as to individuals. The Emerson plan is really a very good one, provided it is not desirable to keep premium increments proportional to production.

Performance Records a Part of the Plan.—The Emerson engineers have taken pains in posting the performance records of individual employees, and this alone goes far to make any plan a success. Where employees have never become used to piece rates the Emerson plan may be highly satisfactory. The very high efficiencies cited for this plan, sometimes as high as 200%, give the impression that the task is not always carefully set. We trust this does not represent usual practice. The lack of a conspicuous task point would naturally mean some scattering of productivities among the different employees of a department, or for any employee over several days. But where they are working in a group, the group limitations prevent this disadvantage. The empiric portion alone is recommended and only where a gradual transition from day wages to high piece rate is considered more suitable than transition by a sudden step bonus.

Empiric Principle in England.—Mr. Spicer[5] says: "Probably the most successful financial incentive plans at present operating in this country are systems for which a collective bonus is paid to the employees as a whole for output in excess of an empirical datum line." He also proposes the use of the composite export index as a criterion for the determination of the points. He thinks this would be a safe index of capacity to pay wages. The location of the points would have to be changed slightly from time to time, so that it is difficult for us to see how such alteration would meet with any better results than the readjustment of any other wage arrangement.

FORMULA FOR EARNING UNDER EMERSON PLAN:

(a) Earning up to 66% = Hours Actual × Rate per Hour of high task

$$E = H_a \quad R_h \tag{1}$$

(b) Earning between

$$67\% \text{ and high task} = \text{Time Wages} + \text{Certain Bonus } \% \times \text{Time Wages}$$

$$E = H_a R_h + B_o \quad H_a R_h$$

Reducing,

$$E = (1 + B_o)\, H_a R_h \tag{2}$$

(For B_o values see Table 45)

[5] In his excellent book, *British Engineering Wages*, 1928.

(c) Earning at and above high task = Time Wages + Savings from Basic Piece Rate + 20% Time Wages

$$E = H_a R_h + (H_s - H_a) R_h + .20 H_a R_h \quad (3)$$
$$E = H_a R_h + H_s R_h - H_a R_h + .20 H_a R_h$$
$$E = H_a R_h + (H_s R_h - .80 H_a R_h)$$

Multiplying binomial by $\frac{H_a}{H_a}$ and simplifying

$$E = H_a R_h + \frac{H_s H_a R_h}{H_a} - .80 H_a R_h \quad (3)$$

$$E = H_a R_h + \left(\frac{H_s}{H_a} - .80\right) H_a R_h$$

Let $\left(\frac{H_s}{H_a} - .80\right) = I$ or % of Incentive $(P_r + B_o)$ (4)

Then Earning or $E = (1 + I) H_a R_h$, (2) only here I has taken the form $\left(\frac{H_s}{H_a} - .80\right)$ and may be used to derive the table from point (100, 120) and beyond.

This proves that at and above task, the earning curve may be considered as a constant function of the production efficiency which was Emerson's aim. That is, one plus I of time wages. Formula (2) gives the appearance of a time plan, but it should be remembered that I is a variable for the whole curve and the formula for I contains the x variable H_s/H_a for different efficiencies.

Key to Symbols

I = Incentive in per cent (Bonus B_o + Premium P_r)
E = Earning in dollars (the vertical variable)
H_s = Hours standard (the horizontal variable)
H_a = Hours actual (a constant)
R_h = Rate per hour in dollars (a constant)

Returning to formula (3) above and simplifying

$$E = H_s R_h + .20 H_a R_h = \left(H_s + \frac{H_a}{5}\right) R_h$$

This is of the well-known form, $y = mx + b$ (see Chapter 4), which proves it a straight line with intercept. In other words, the earning curve is parallel to basic piece rate and at a constant bonus ($.20 H_a R_h$) above it. When projected back, this straight line has an intercept on the vertical axis of this same amount. The formula reveals that while the Emerson earning curve above task is parallel to basic piece rate and above it in values paid, its slope is less than

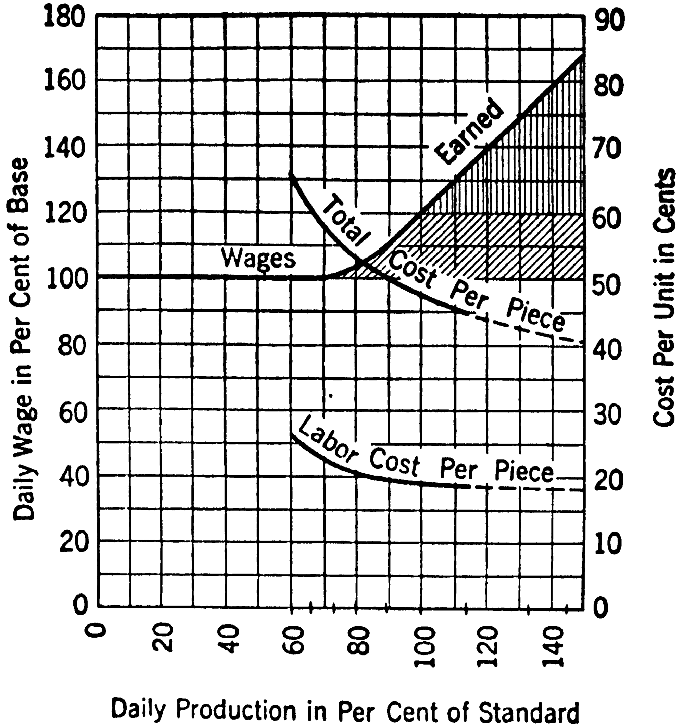


Figure 66. Emerson Efficiency-Bonus Plan

TABLE 46. EMERSON EFFICIENCY-BONUS DATA

Per Cent of Production H_s/H_a	Per Cent of Total to Base Wage for Full Day $E/H_a R_h$	Total Daily Wage in Dollars E	Number Pieces per Day	Time Saved per 8-Hr. Task in Hours $H_s - H_a$	Labor Cost per Piece in Dollars	Total Cost per Piece in Dollars
60	100	3.84	14.4	− 5.3	.27	.66
66	100	3.84	16.0	− 4.0	.24	.60
73	101	3.88	17.5	− 3.0	.22	.56
80	104	4.00	19.2	− 2.0	.21	.53
89	110	4.23	21.4	− 1.0	.20	.50
100	120	4.61	24.0	0.	.19	.47
114	134	5.16	27.4	1.0	.19	.45
133	153	5.89	32.0	2.0	.18	.42
145	165	6.34	34.8	2.5	.18	.41

the piece rate for its starting point. For instance, Gantt earning has the same start (100, 120) and diverges above with slope of 1.2 R_h paying more generous earnings as H_s/H_a increases. For an ordinate value of 120, the slope must be 1.2 to have a piece rate slope. Finally, the Emerson formula showing piece rate plus bonus is true but misleading, for this piece work is basic piece work (100, 100) slope 1.0 and not the one for its own starting location. To compare with the piece rate for the same starting point, use formula (3) under Emerson and formula (1) under Gantt (Chapter 9). These formulas seem complex, but the table of efficiencies and corresponding bonuses (Table 45) is always used in practice.

Cost per Piece.—The total cost per piece under the Emerson plan is slightly higher than under the Gantt plan, but is without the high incentive value of the latter. Due to the lack of any task emphasis, the productions will scatter and the consequent average production is sure to be lower than it would be under plans where the task is definitely seen. Through the range for which we recommend it, 70% to 100% task, this cost is about the average of the plans.

Example of the Emerson Plan.—A mid-west bridge and iron works has used this plan since 1915; 165 men of a 320 payroll are on the plan. It is based on carefully set job standards and individual production records are used. Two clerks take care of the plan in the factory and one in the office. The management claims that it has increased production and lessened supervision. A case is cited of an increase from 2,200 holes punched per day under the former time plan to 6,000 per day under the present plan (Figures 67, 68, and 69). The daily earning ranges from $5.40 to $8.31. The three most essential forms are given and they are self-explanatory.

Wennerlund Efficiency-Bonus Plan.—E. K. Wennerlund, one of Mr. Emerson's associates at the time the Emerson methods were developed on the Santa Fe Railroad, has worked out an empiric incentive (Table 47) which connects time wages below 75% high task and piece rate above high task (Figure 70). This plan was adopted by General Motors in 1912 and widely used by them until 1937 when it was decided that time rates were more practical for their conditions. (See Chapter 2.) The empiric scale is much like that used by Emerson except that it starts at a higher production, goes up a little more rapidly in earning at first, and then coincides with the Emerson scale, giving 20% bonus at high task. From here on, it coincides with the earning of the Gantt and Merrick plans as it uses the high piece rate. In computing earnings, all time is tabulated

No. 281 Name Failing #1	
Work Done 90 — 29,880	
Std. Hrs. 18.00	Act. Hrs. 9.00
Efficiency 200	Bonus % 86
Wages 6.39	Bonus 5.50
Date 9-13 Issued	No.

No. 256 Name @ #1	
Work Done	
Std. Hrs.	Act. Hrs.
Efficiency	Bonus %
Wages	Bonus 5.26
Date 9-13 Issued	No.

Figure 67. Employee Time Ticket Under Emerson Plan

9.0 — 18.00

Cont. No.	Finish	Operation		Mach. No.	Check	Time	Rate	Wages
6680	9.0	Punch		#1	281			
Date	Start	Actual	Standard	Schedule 5 Pk. per hr.	256			
9-13	4.0	5.0	10.00		97			
No. Pcs.	Description		Each	Total	367			
50	Pk. 62A80-#5		332	16,600				
				90	29,880			

MAIN SHOP

Figure 68. Job Ticket Under Emerson Plan

MACH.	OPER.	CH. NO.	NAME	WORK PCS.	WORK UNITS	TOTAL TIME	TIME STD.	TIME ACT.	EFFY.	BONUS %	WAGE		BONUS		Move	Repair	Set Up	REMARKS
#1	Punch	281	Failing	90	29,880	9.0	18.00	9.0	200	86	6.39		5.50					6680;7509 Shell Plates
		256									6.12		5.26					
		97									5.22		4.50					
		367									4.32		3.72					
#48	"	80	Sehring	91	34,180	9.0	17.33	9.0	192	81	5.40		4.37					7509;6680
		372									4.32		3.50					Bottom Rectangular Pl.
		373									4.32		3.50					
80	"	308	Gromala	36	11,888	8.5 0.5	11.89	8.5	140	47	4.42		2.08			0.5		6680 Bottom Sketch Pl.
		470									4.08		1.92					
5457	Bl. & Sf.	207	Sykucki	40	1000	8.0 1.0	10.71	8.0	134	42	4.80		2.02		10			7509;7523;
		139		94	83¼"						3.84		1.61					
		401									3.84		1.61					

Figure 69. Payroll Sheet for Emerson Plan

in decimals of the standard or task time. This provides a table of efficiencies and corresponds to the table of empiric bonuses. It will be noted that above task the increment of incentive for each 1% increment of production efficiency is 1.2. As this earning curve begins at the point (100, 120), it will be seen that the 1.2 increment is in direct proportion to the earning at that starting point and is, of course, piece rate. Any constant increment would give a straight line earning, but only the increment proportional to the earning of the starting point can be a piece rate.

Plan Much Used for Groups.—The Wennerlund plan has been applied to individuals and to groups. When different operations are performed during the same week, the standard hours for each are figured, added together and then compared with the actual hours worked to derive the total efficiency. In the case of a group, the completed pieces and standard hours are usually the same for all members of the group. If not, the actual hours of the individuals are totaled and compared with the total standard hours. After this, group efficiency is derived, the incentive corresponding to it is added separately to each employee's base wage.

Advantages of the Plan.—Due to the piece rate, this is one of the most generous of the efficiency bonus group for high production. It is in every way superior to the original Emerson plan from the employee's point of view and also from the employer's provided he really wishes to give the employee all wage saving from the point (100, 120). It is much more effective in getting the full response of employees than the Emerson plan and avoids the decreasing increments of earning which employees are likely to resent if they are used to the piece rate principle. The only fault is that the task location is not especially indicated. For this reason, individual productions under the Wennerlund plan will vary somewhat.

FORMULA FOR EARNING: (Compare with Emerson formulas.)

Earning up to 75% of high task = Hours Actual × Rate per Hour

$$E = H_a \quad R_h$$

Earning from 75% of high task to task $= \frac{\text{Time}}{\text{Wages}} + \text{Certain } \% \times \frac{\text{Time}}{\text{Wages}}$

$$E = H_a R_h + \quad B_o \quad H_a R_h$$

$$E = (1 + B_o)\, H_a R_h$$

(For B_o values see Table 47.)

Earning at and above high task = Hours Standard × 120% Rate per Hour

$$E = 1.20\, H_s R_h$$

TABLE 47. WENNERLUND GROUP-INCENTIVE SCALE

Efficiency in % of High Task	Incentive in % of Time Wage	Efficiency in % of High Task	Incentive in % of Time Wage	Efficiency in % of High Task	Incentive in % of Time Wage
	Bonus				
75	1.0	117	40.4	159	90.8
76	1.6	118	41.6	160	92.0
77	2.2	119	42.8	161	93.2
78	2.8	120	44.0	162	94.4
79	3.4	121	45.2	163	95.6
80	4.0	122	46.4	164	96.8
81	4.6	123	47.6	165	98.0
82	5.2	124	48.8	166	99.2
83	5.8	125	50.0	167	100.4
84	6.4	126	51.2	168	101.6
85	7.0	127	52.4	169	102.8
86	7.6	128	53.6	170	104.0
87	8.2	129	54.8	171	105.2
88	8.8	130	56.0	172	106.4
89	9.4	131	57.2	173	107.6
90	10.0	132	58.4	174	108.8
91	11.0	133	59.6	175	110.0
92	12.0	134	60.8	176	111.2
93	13.0	135	62.0	177	112.4
94	14.0	136	63.2	178	113.6
95	15.0	137	64.4	179	114.8
96	16.0	138	65.6	180	116.0
97	17.0	139	66.8	181	117.2
98	18.0	140	68.0	182	118.4
99	19.0	141	69.2	183	119.6
*	Incentive	142	70.4	184	120.8
100	20.0	143	71.6	185	122.0
101	21.2	144	72.8	186	123.2
102	22.4	145	74.0	187	124.4
103	23.6	146	75.2	188	125.6
104	24.8	147	76.4	189	126.8
105	26.0	148	77.6	190	128.0
106	27.2	149	78.8	191	129.2
107	28.4	150	80.0	192	130.4
108	29.6	151	81.2	193	131.6
109	30.8	152	82.4	194	132.8
110	32.0	153	83.6	195	134.0
111	33.2	154	84.8	196	135.2
112	34.4	155	86.0	197	136.4
113	35.6	156	87.2	198	137.6
114	36.8	157	88.4	199	138.8
115	38.0	158	89.6	200	140.0
116	39.2				

* Note that from here on, the incentive increases 1.2% for every 1% efficiency. This slope for the ordinate starting level of 120 is exactly piece rate.

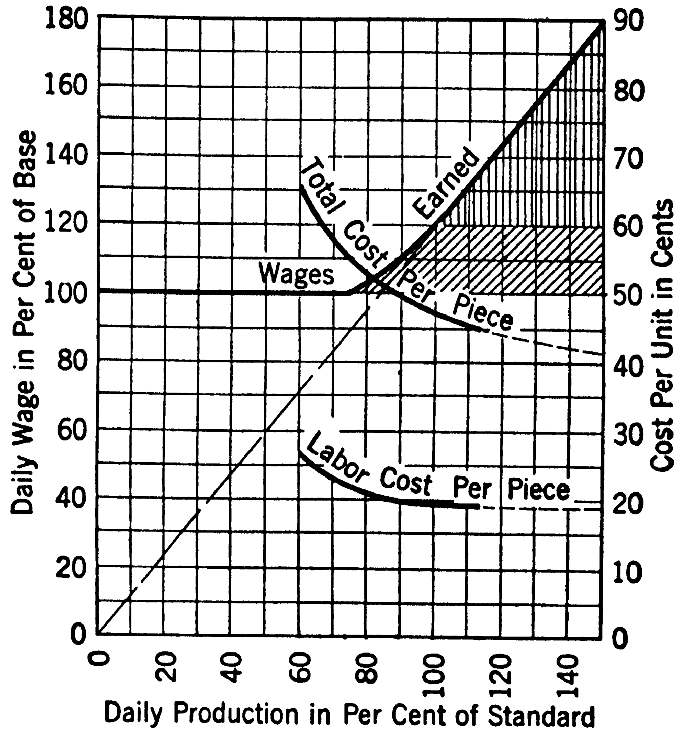


Figure 70. Wennerlund Efficiency-Bonus Plan

TABLE 48. WENNERLUND EFFICIENCY-BONUS DATA

Per Cent of Production H_s/H_a	Per Cent of Total to Base Wage for Full Day $E/H_a R_h$	Total Daily Wage in Dollars E	Number Pieces per Day	Time Saved per 8-Hr. Task in Hours $H_s - H_a$	Labor Cost per Piece in Dollars	Total Cost per Piece in Dollars
60	100	3.84	14.4	− 5.3	.27	.66
66	100	3.84	16.0	− 4.0	.24	.60
73	100	3.84	17.5	− 3.0	.22	.56
80	104	3.99	19.2	− 2.0	.21	.53
89	109	4.20	21.4	− 1.0	.20	.50
100	120	4.61	24.0	0.	.19	.47
114	137	5.25	27.4	1.0	.19	.45
133	160	6.14	32.0	2.0	.19	.43
145	174	6.67	34.8	2.5	.19	.42

Cost per Piece.—The total costs for the Wennerlund plan are apparently slightly higher than under the Emerson plan, but, as the average production under the Wennerlund plan is likely to be higher than under that plan, the total cost is lower despite the higher direct labor cost. That is, the average response point is at an advanced location. The direct labor cost curve is horizontal as in piece rate, for above task production. (See Chapter 7, High Piece Rate Plan.)

Example of the Wennerlund Plan.—A mid-west company making hoists began using this plan in 1919 partly on an individual basis and partly on a group basis as is usual with the Wennerlund plan. A 75% sharing plan which was not adjusted to standard costs had previously been in operation; 700 men of the 1,200 payroll are on the present plan. It is based on carefully set job standards and individual production records are used. The management claims that unit costs have been reduced from 5% to 35% and that the working force is entirely satisfied. Efficiencies of 90% to 125% and earnings of $.75 to $.95 per hour are usual. On the factory side, eight checkers for routing and ten men for time study are required. On the office side, three clerks for payroll calculation are required. The only conceded weakness of the plan is that it is too complicated for some employees to understand. The group feature is used mainly for assembly operations and is considered very effective. There is also a bonus for shop executives.

The Ernst and Ernst Plan.—This plan provides differential bonus changes for three production zones.[6]

Earning	up to 75%	high task	= time wages
			$E = H_a R_h$
"	above "	" "	$E = H_a R_h + B_o H_a R_h$
Between	75–90%	efficiency,	$B_o = .6$
"	90–100%	"	$B_o = 1.0$
At	100%	"	$B_o = 1.2$
Thereafter	(1.2 piece rate)		$E = 1.2\, H_a R_h$

[6] *Automotive Industries,* April 12, 1930.

CHAPTER 14

EMPIRIC PLANS WITH STEP BONUSES

> High efficiency men encourage the other men. Place no limit on amounts a man should earn as bonus.—C. E. KNOEPPEL.

Knoeppel Efficiency-Bonus.—This plan is a modification of the Emerson plan, devised by C. E. Knoeppel.[1] It guarantees wages up to 67% of task and provides empiric bonuses for points of efficiency between 67% and 100% (Table 49). These points are slightly higher than in the Emerson plan up to 85% efficiency, and are practically the same as in the Emerson plan from 90% to 100% of high task. At this point there is a step of 5%, making a total of 25% bonuses (Figure 71). In devising his plan, Mr. Knoeppel had in mind the piece rate passing through the point (82, 100). He intended his bonus to hold back enough from this earning before task to finance the whole step at task as well as additional premiums thereafter. Like Emerson's curve, his curve above task is parallel to basic piece rate. For comparison of slopes see Chapter 4.

A slide rule has been devised for computations under this plan. The step is small compared to the steps of the Taylor, Gantt, Diemer, and Merrick plans, but it definitely indicates the amount of work desired. It should be more effective in steadying production than other efficiency plans which have no step. Average production ought, therefore, to be higher than under the Emerson plan and the consequent total cost per piece ought to be lower.

FORMULA FOR EARNING:

Earning up to 66% task = Hours Actual × Rate per Hour

$$E = H_a \quad R_h$$

Earning from 66% up to task = Time Wages + Certain % of Time Wages

$$E = H_a R_h + B_o \; H_a R_h$$

or

$$E = (1 + B_o)\, H_a R_h \text{ (For } B_o \text{ see Table 49)}$$

Earning at and above task = Time Wages + Earnings Saved + .25 Time Wages

$$E = H_a R_h + (H_s - H_a)\, R_h + .25 \; H_a R_h$$

$$\text{Reducing, } E = R_h\,(H_s + .25\, H_a)$$

[1] C. E. Knoeppel, *Installing Efficiency Methods.*

Further analysis of formula above task may be made by substituting .25 for .20 in Emerson formulas.

Key to Symbols

B_o = Bonus in per cent
E = Earning in dollars (the vertical variable)
H_s = Hours standard (the horizontal variable)
H_a = Hours actual (a constant)
R_h = Rate per hour in dollars (a constant)

TABLE 49. KNOEPPEL EFFICIENCY-"BONUS" SCALE

Efficiency in % of High Task	Bonus in % of Base Wage	Efficiency in % of High Task	Bonus in % of Base Wage
67	.0	86	7.5
68	0.5	87	8.0
69	0.7	88	8.5
70	1.0	89	9.0
71	1.4	90	10.0
72	1.7	91	11.0
73	2.2	92	12.0
74	2.6	93	13.0
75	3.0	94	14.0
76	3.3	95	15.0
77	3.7	96	16.0
78	4.0	97	17.0
79	4.4	98	18.0
80	5.0	99	19.0
81	5.2	100	25.0
82	5.6	Increments oi 1% thereafter	Increments of 1% thereafter $B_o + P_r = I$
83	6.0		
84	6.5		
85	7.0		

For piece rate from (100, 125) increments would need to be 1.25% bonus per 1% production.

Cost per Piece.—The direct labor cost under the Knoeppel plan is slightly more than it is under the Emerson plan, but the total cost per piece is less, due to the superior drawing and steadying power of the small step.

Differential Plans Which Are Simpler.—Henry Atkinson[2] describes two plans used in England which have earning curves similar to the empiric step plans. In one (Figure 72) a high piece rate is used between 80% of high task and high task. The earning at the latter point is 125% of base wages. There is then a step of 10% relative to base wages, so that the earning continues from the point (100, 135) parallel to the first high piece rate. This plan was adopted by H. W. Allingham after a conference with trade union officials. Up to 80% of high task $E = H_a R_h$, between 80% and

[2] *A Rational Wages System*, 1917.

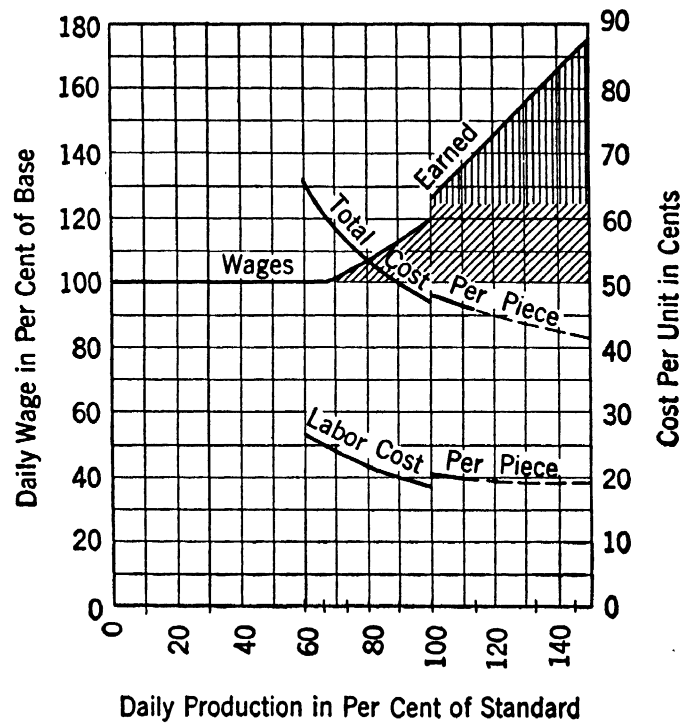


Figure 71. Knoeppel Efficiency-Bonus Plan

TABLE 50. KNOEPPEL EFFICIENCY-BONUS DATA

Per Cent of Production H_s/H_a	Per Cent of Total to Base Wage for Full Day $E/H_a R_h$	Total Daily Wage in Dollars E	Number Pieces per Day	Time Saved per 8-Hr. Task in Hours $H_s - H_a$	Labor Cost per Piece in Dollars	Total Cost per Piece in Dollars
60	100	3.84	14.4	− 5.3	.27	.66
66	100	3.84	16.0	− 4.0	.24	.60
73	102	3.94	17.5	− 3.0	.23	.57
80	105	4.03	19.2	− 2.0	.21	.53
89	109	4.21	21.4	− 1.0	.20	.50
100	125	4.80	24.0	0.	.20	.48
114	138	5.33	27.4	1.0	.20	.46
133	158	6.08	32.0	2.0	.19	.43
145	169	6.51	34.8	2.5	.19	.42

100% $E = 1.25\ H_s\ R_h$, and above 100% $E = 1.25\ H_s\ R_h + .10\ H_a\ R_h$. In the other plan (Figure 73) a high piece rate is used between 75% of high task and high task. The earning at the latter point is 133⅓% of base wages. There is then a step of 5% relative to base wages, so that the earning continues from the point (100, 138⅓) parallel to the first high piece rate. Despite the small bonuses,

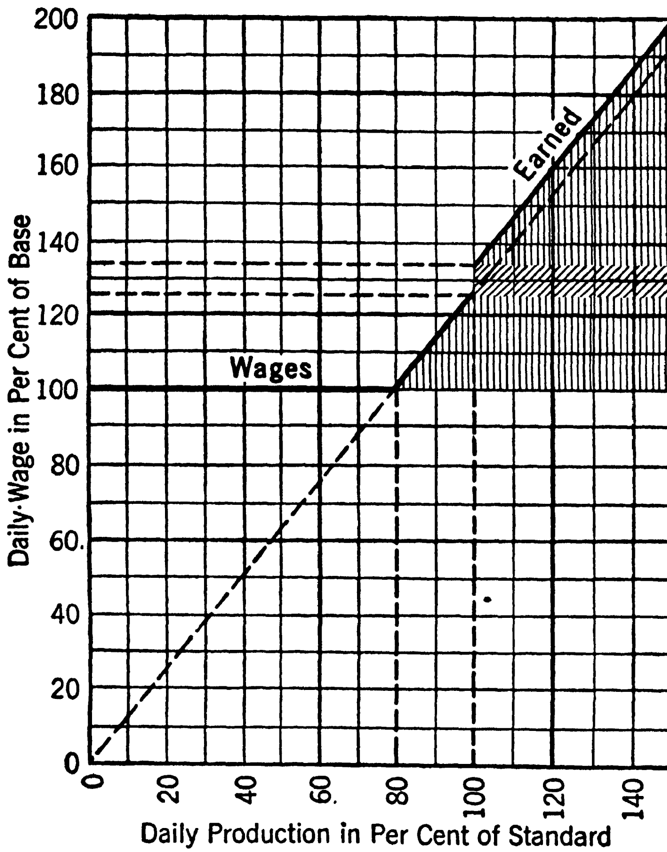


Figure 72. The Allingham Plan

these plans give high earnings, are strong, and are simpler to figure than the empiric plans which resemble them. Neither should, however, be confused with differential piece rate plans.

Bigelow Bonus Plan.—The plan (Table 51) originated by Carle M. Bigelow,[3] is another modification of the Emerson plan. Mr. Bigelow maintains that the first fundamental of a wage payment plan is guarantee of a living wage, varying for various operations in a plant in terms of intrinsic skill required, time required for training, physical hazard, physical and mental fatigue involved, etc. He says,

[3] C. M. Bigelow, *Management in the Woodworking Industry.*

"These guaranteed rates should be the average competitive wage in the community for similar work in plants not using an incentive method of payment, that is, a fair price for an average worker. These rates should be varied from time to time as the price of labor, living conditions and other relevant influences fluctuate."

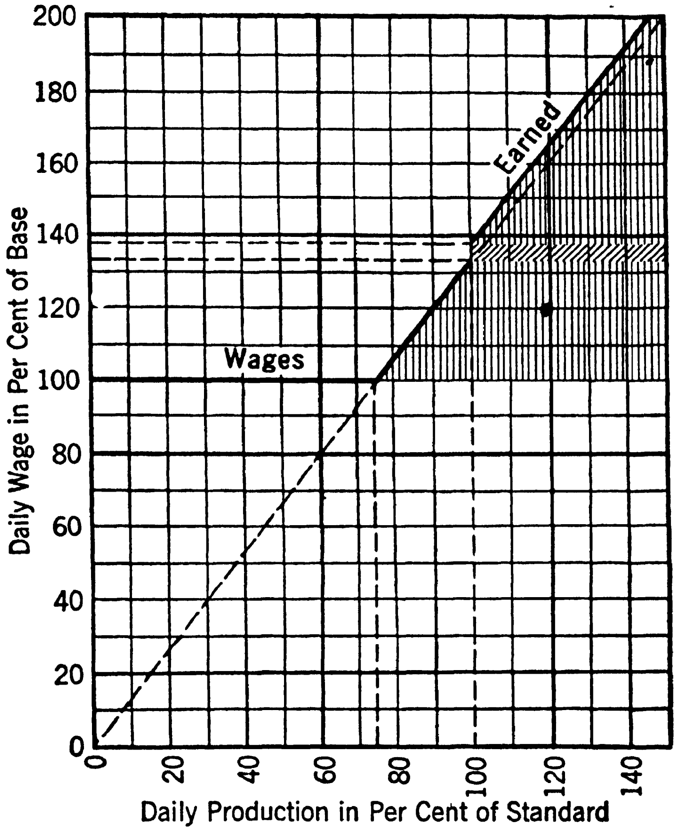


Figure 73. The Atkinson Plan

The second fundamental, Mr. Bigelow maintains, is reward by substantial increase in pay for reasonable effort in terms of higher efficiency on the part of an average worker. That is, assuming that average employees are 50% or 60% efficient, upon attainment of a determined efficiency—for example, at 70%—they should be automatically rewarded with a bonus of from 5% to 10% over their guaranteed rate (Figure 74). As they improve their effort, this bonus should increase in a parabolic curve, to 95% of maximum[4] task, which is always expressed as 100%. For instance, assuming

[4] If Mr. Bigelow means by "maximum" a perfection task, the examples and charts here shown are a little unjust to his plan. In fact, a perfection task would bring his step at 70% near to what we use here as high task and would do much to offset the present criticism. On the other hand, the Knoeppel curve is admitted correct as charted and in the Bigelow-Knoeppel combination a step is placed at 70% of this high task.

an employee receives a 5% increase at 70% efficiency in a particular case, it might be found that at 75% the bonus would be 6%. Then, 8% at 80%, 11% at 85%, 15% at 90%, and 20% at 95%. While this involves a slight increase in cost at the 70% point, the possibility of increasing the percentage as efficiency is increased, carries the employees rapidly into upper points of the curve where they are not only amply rewarded, but the cost is constantly decreased as each higher percentage of efficiency is reached. Above 95% the curve increases more steeply. For exceptional operatives who can maintain production in excess of standard, the incentive is usually increased 1% for each additional 1% in efficiency. As the empiric points end at (100, 125), the corresponding piece rate increment would be 1.25% for every 1% production.

TABLE 51. BIGELOW EFFICIENCY-BONUS SCALE
Efficiencies Below 70% High Task, 91% of Base Wage

Efficiency in % of High Task	Bonus in % of Base Wage	Efficiency in % of High Task	Bonus in % of Base Wage
70	.0	86	9.9
71	.3	87	10.9
72	.7	88	12.1
73	1.1	89	13.4
74	1.5	90	15.0
75	2.0	91	16.0
76	2.5	92	17.0
77	3.0	93	18.0
78	3.6	94	19.0
79	4.3	95	20.0
80	5.0	96	21.0
81	5.7	97	22.0
82	6.4	98	23.0
83	7.2	99	24.0
84	8.1	100	25.0
85	9.0		

For every one point on up, one additional point. For piece rate from this point. the increments would need to be 1.25% bonus per 1% production.

Incentive Interpreted in Terms of Hourly Rate.—Rates are so expressed that the individual employee knows that for maintaining a certain production he will obtain a certain percentage of his hourly rate. Instead of telling him that when he is 95% efficient he will obtain a bonus of 20%, simple instruction cards show him how much he will receive in terms of his hourly rate for every number of units produced per hour or per day. This makes the method as easily comprehended by an average employee as simple piece rates. The payroll calculation involves practically no additional expense.

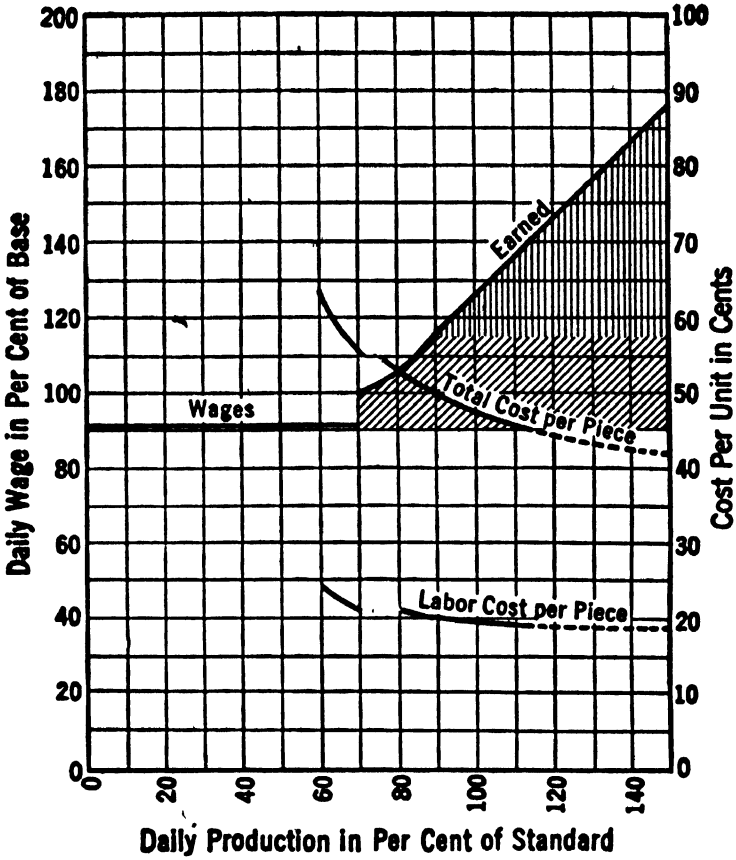


Figure 74. Bigelow Efficiency-Bonus Plan

TABLE 52. BIGELOW EFFICIENCY-BONUS DATA

Per Cent of Production H_s/H_a	Per Cent of Total to Base Wage for Full Day $E/H_a R_h$	Total Daily Wage in Dollars E	Number Pieces per Day	Time Saved per 8-Hr. Task in Hours $H_s - H_a$	Labor Cost per Piece in Dollars	Total Cost per Piece in Dollars
60	91	3.49	14.4	− 5.3	.24	.63
66	91	3.49	16.0	− 4.0	.22	.58
73	101	3.88	17.5	− 3.0	.22	.56
80	105	4.03	19.2	− 2.0	.21	.53
89	113	4.35	21.4	− 1.0	.20	.50
100	125	4.80	24.0	0.	.20	.48
114	139	5.34	27.4	1.0	.19	.45
133	158	6.07	32.0	2.0	.19	.43
145	170	6.53	34.8	2.5	.19	.42

The plan is, therefore, similar to the Parkhurst plan, except that the step is at a little higher location, although still too low for its best effect. This plan contributes nothing advantageous over the Emerson plan and in its main variation from that plan is of doubtful value. If the guaranteed time rate is the usual base wage, then the step at 70% of task gives too high a wage for so low an efficiency. Some employees already working above this point would be sure to drop back to 70% efficiency which they could do without loss, relative to former earnings. If the guaranteed time rate is a lower "hiring rate," it will serve as a negative incentive, but will be difficult to carry out in competition with other employers.[5]

FORMULA FOR EARNING:

Earning up to 70% task = 91% Base Wage

$$E = .91\, H_a R_h$$

Earning from 70% to 100% task and above = Time Wages + Certain % × Time Wages

$$E = H_a R_h + B_o\, H_a R_h$$

$$E = (1 + B_o)\, H_a R_h$$

(For B_o values see Table 51)

Cost per Piece.—If the low guarantee of the Bigelow plan can be used without labor difficulties, this plan furnishes a strong punitive incentive and may reduce the unit costs for efficiencies below 70% of task. For costs between 70% and 100% of task, they are slightly higher than for the Emerson plan. For costs between 100% of task and beyond, see the Knoeppel plan.

Bigelow-Knoeppel Efficiency-Bonus Plan.—In May, 1926, Bigelow, Kent, Willard and Company announced in their bulletin a wage plan incorporating features from both the separate Bigelow and Knoeppel plans. The plan (Figure 75) begins with a "hiring" or learner's rate 40% below the usual day wages.[6] As they increase production, new employees are advanced on a straight line scale from the hiring rate to day rate. This line is the average of a reverse curve called the effort line. (See Chapter 17.) An employee below 70% task "should be considered as an apprentice and rewarded in terms of his attainment of skill." When he reaches 70% of the high

[5] In *Management's Handbook*, we presented the plan as guaranteeing the base wage but have since learned that this is not the practice. We, therefore, present it now as guaranteeing a lower rate.

[6] The bulletin, already mentioned, locates this at 20% below base wages but a later announcement makes it 40% below. See *The Management Review*, A. M. A., September, 1928.

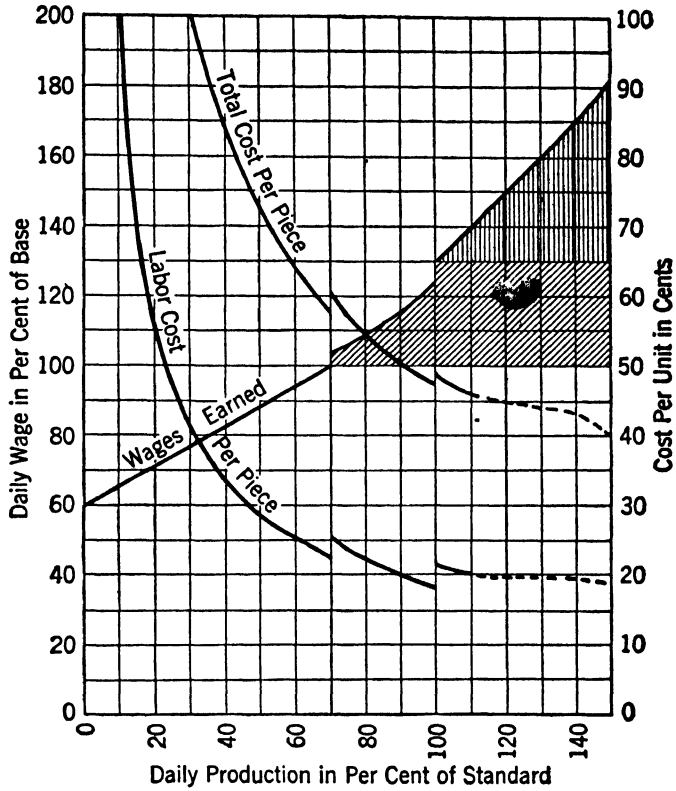


Figure 75. Bigelow-Knoeppel Efficiency-Bonus Plan

TABLE 53. BIGELOW-KNOEPPEL EFFICIENCY-BONUS DATA

Per Cent of Production H_s/H_a	Per Cent of Total to Base Wage for Full Day $E/H_a R_h$	Total Daily Wage in Dollars E	Number Pieces per Day	Time Saved per 8-Hr. Task in Hours $H_s - H_a$	Labor Cost per Piece in Dollars	Total Cost per Piece in Dollars
0	60	2.30	0	fictitious	2.30*	6.14*
10	66	2.53	2.4	− 72.0	1.05	2.77
20	71	2.74	4.8	− 32.0	.57	1.49
30	77	2.97	7.2	− 18.6	.41	1.06
40	83	3.18	9.6	− 12.0	.33	.85
50	89	3.39	12.0	− 8.0	.28	.72
60	94	3.62	14.4	− 5.3	.25	.64
66	97	3.73	16.0	− 4.0	.23	.59
73	105	4.05	17.5	− 3.0	.23	.57
80	108	4.15	19.2	− 2.0	.22	.54
89	114	4.38	21.4	− 1.0	.20	.50
100	130	4.99	24.0	0.	.21	.49
114	144	5.53	27.4	1.0	.20	.46
133	164	6.29	32.0	2.0	.20	.44
145	176	6.76	34.8	2.5	.19	.42

* Not per piece.

task, he is given a 5% bonus (Table 54). From a third description of the plan,[7] day wages are guaranteed below 70% of task, but the two sources above cited do not indicate this. We have analyzed the plan according to the two documents which are more alike.

From 70% to 100% of high task, employees are paid according to an empiric bonus—efficiency scale—which is terminated at task with a small step bonus amounting to 5% of day wages, or about 4% of wages at 99% of task. Above the point (100, 130) the earning is a straight line falling away from the piece rate of (100, 130), but parallel to basic piece rate as in the case of the original Emerson earning curve. By virtue of the two small steps and the empiric bonuses, the location of this earning curve for above task productions is high. If the plan can hold the average response just above task, it will succeed in combining high wages and reasonably low unit total costs.

TABLE 54. BIGELOW-KNOEPPEL EFFICIENCY-BONUS SCALE

Efficiency in % of High Task	Bonus in % of Base Wage	Efficiency in % of High Task	Bonus in % of Base Wage
70	5	90	15
75	6	95	20
80	8	100	(25)*
85	11		

* Plus 5% step or 30.
For every additional 1%, increments of 1%. For piece rate from this point, the increments would need to be 1.30% bonus per 1% production.

Comparison with Other Plans.—It is necessary to stress the fact that total costs may be low because the heading of the bulletin mentions low labor costs. As we have explained (see Chapter 3), the waste elimination work which alone can materially reduce unit labor costs, must come from separate measures preceding the standardization of tasks. A group incentive will assist this process somewhat; an individual incentive very little. Direct labor cost reduction cannot result from the fixed earning curve itself, unless the curve is considerably less than the corresponding piece rate. If the earning curve is nearly as high as the corresponding piece rate, or is, in other words, a nearly constant and generous rate, it can only lower unit total costs. In the alternative case of a low slope earning curve, unit labor costs will decline as production increases, but production is not likely to increase enough to lower unit total costs.

[7] A blueprint, issued in 1928.

The Bigelow-Knoeppel earning curve from task starts above the usual piece rates. The earning is generous and the slope of the earning curve is not far from constant. On the other hand, the step bonus at 100% task is too small to be a major inducement and will not always hold the average response up to task. It would have been much surer in its effect if the earlier step, which is of doubtful value at so low a point as 70% of task, had been combined with it. The trouble with this plan is that the joint designers have retained too many of the characteristics of the two parent plans and in so doing have raised wages without getting a strong, simple plan. For instance, at 95% of task employees will receive as much as under the Gantt, Merrick, Diemer, Emerson, Wennerlund plans at task. Hence some employees will be content to stay below the task.

As pointed out elsewhere, simplicity and maximum effect cannot be attained by combining step bonuses with anything more complex than day or piece rates. A certain degree of complexity may be justified if a plan is stronger thereby, but complexity without assured strength is undesirable. It is never wise to put two small steps in an empiric type of earning curve.

FORMULA FOR EARNING:

Earning up to 70% high task $= \frac{4}{7}$ Piece Wages $+ \frac{3}{5}$ Time Wages

$$E = \frac{4}{7} H_s R_h \qquad + \frac{3}{5} H_a R_h$$

$$E = (20\, H_s + 21\, H_a)\, \frac{R_h}{35}$$

This is a (40-60) constant sharing curve through what is practically low task, 70% efficiency. This portion of the plan is simple and may well be used for employee beginners or as a minimum guarantee.

Earning from 70% high task to 100% task = Time Wages + Certain Bonus % × Time Wages

$$E = H_a R_h + B_o\, H_a R_h$$

$$E = (1 + B_o)\, H_a R_h$$

(For B_o values see Table 53)

Earning at and above high task = Time Wages + Savings from Basic Piece Rate + .30 Time Wages

$$E = H_a R_h + (H_s - H_a) R_h \quad + .30\, H_a R_h$$

$$E = H_s R_h + .30\, H_a R_h$$

$$E = \left(H_s + \frac{3H_a}{10}\right) R_h$$

This means .3 time wages as total bonus plus all time saved under basic piece rate, not under the corresponding piece rate of (110, 130). In other words, the earning curve above task is parallel to the basic piece rate curve but 30% above it, that is, a (70-30) constant sharing.

Cost per Piece.—The total cost per piece of the Bigelow-Knoeppel plan below 70% of task is extremely low. From there to task, it is much like that of the Emerson and Bigelow plans. Above task, the total cost per piece is high as the earning is generous without a large enough step or a steep enough slope to assure a large average departmental production.

Example of Bigelow-Knoeppel Plan.—Bigelow, Kent, Willard and Company furnishes this case but with the client name withheld. The plan was first applied about 1926 to 850 men working a 9-hour day, and replaced day and piece work. Carefully set standards are used. The plan is supported by individual production records and a supervisor's bonus. The typical efficiency cited is 92% and the typical earning is 17% above the local competitive wage scale. The bonus work, exclusive of other clerical work, requires two men in the factory and two men in the office. Three men are used in the factory for cost finding, payroll, and production control work. Three other men are used in the office for this same work. The benefits claimed are, "ever reducing cost and increasing wages, corresponding to increasing workmen efficiency."

CHAPTER 15

ACCELERATING PREMIUM PLANS

> For highest efficiencies the ideal earning curve would be one which is concave on the upper side.—F. A. HALSEY.

Minimum Wage Injects New Problem.—Whenever a new rule is imposed upon a game, new tactics follow in playing that game. The Fair Labor Standards Act made illegal the low end of all earning curves which extend to the origin. This did not affect wage incentives particularly because that end of the earning curves rarely came into effect anyway. Nevertheless, the new requirement of a minimum time wage has changed one of the rules in the wage payment game and new designs might as well lie wholly within the permissible field. In other words, it is now in order to start an earning curve to pay the legal minimum at zero efficiency. If shocked by that statement remember that ordinary time wages have always committed an employer to the *full* base rate at zero efficiency, that is, on paper. As seen in a previous chapter, some of the less steep constant sharing plans (Figure 30) can be arranged to start at this new locus and such arrangements are very satisfactory through intermediate efficiencies. They do not, however, continue to be satisfactory through points of high efficiency. If it is desired to have a single smooth earning line start at, say, (0, 83⅓), or $.40 per hour, pass the high task incentive point of (100, 120) and continue at a satisfactory slope, then a curve with an ascending slope must be used. Either the conjugate hyperbola or the vertical parabola can meet these or similar requirements. This chapter will describe several such plans by which a variety of slopes may be obtained as desired. These accelerating plans were developed[1] by Hugo E. Hanser of Brooklyn, N. Y., and are here reproduced with his permission. The first phase of the study is based on passing the conjugate hyperbola through two points representing any minimum guaranteed wage ratio (B) to a standard day's wage and a high task efficiency-earning point (100, 120). The second phase of the study is based on passing a vertical parabola through the same two points and at the same time meeting a third condition that the rate of wage payment

[1] The development was made in connection with an Administrative Engineering course, graduate level, given by the author, 1940-1941.

shall not fall below that of high piece work rate of wages. Also the two types of curves are considered in combination, either by means of an unweighted or weighted average. A sufficient number of computations have been made to show the range of the curves in their application to possible wage rates. The 1.20 piece rate earning line is taken as the basis for comparison; and will be referred to simply as high piece rate. All plans are based on a minimum guaranteed wage at no production and on high task wage 1.20 $H_a\ R_h$ at 100% task production, while a standard day's wage is presumed to lie at 1.00 $H_a\ R_h$. In Figure 76, the shaded area is determined (Figure 9) by the various plans already described, and the straight line corresponds to high task piece rate earning. Superimposed on this background are three curves, of which curve (H) is an Hyperbolic plan, curve (P) is a Parabolic plan, and curve (A) is the unweighted arithmetic mean of these two. See also Figure 80. These earning curves are repeated later on the basis of the formulae which make up the body of the analysis and the same hypothetical data used throughout the book. One further assumption has been made, and that has necessarily been a minimum wage guarantee at $.40 per hour or 83⅓% of standard time wage used in all the book examples.

Standard Curves Bent to New Uses.—In arriving at the type of curves to be used for computing the wage rate under these proposed plans, first recourse is necessarily made to the variable hyperbola and the variable parabola. Both curves are generally known in their normal horizontal position, but since they are convex to the side in that position, the upright curves are used here. In the upright position both curves present traces concave upwards which provide the type of curves desired. The upright hyperbola, mathematically known as the "conjugate," is defined by the expression,

$$\frac{x^2}{a^2} - \frac{y^2}{b^2} = -1 \qquad (1)$$

whereas the variable upright parabola is defined by the expression,

$$y = ax^n + b \qquad (2)^*$$

The passing of one of each type and one a hybrid of these curves through the aforesaid points, their conversion into the standard incentive nomenclature of the present text, and their comparison, by means of "analyzers," with the various other types of wage incentive formulas constitutes the part of this development shown in this chapter. Earning curves for other starting points appear in groups, Figures 79 and 82, and details for these are shown in Appendix B.

* See Barth variable sharing plan.

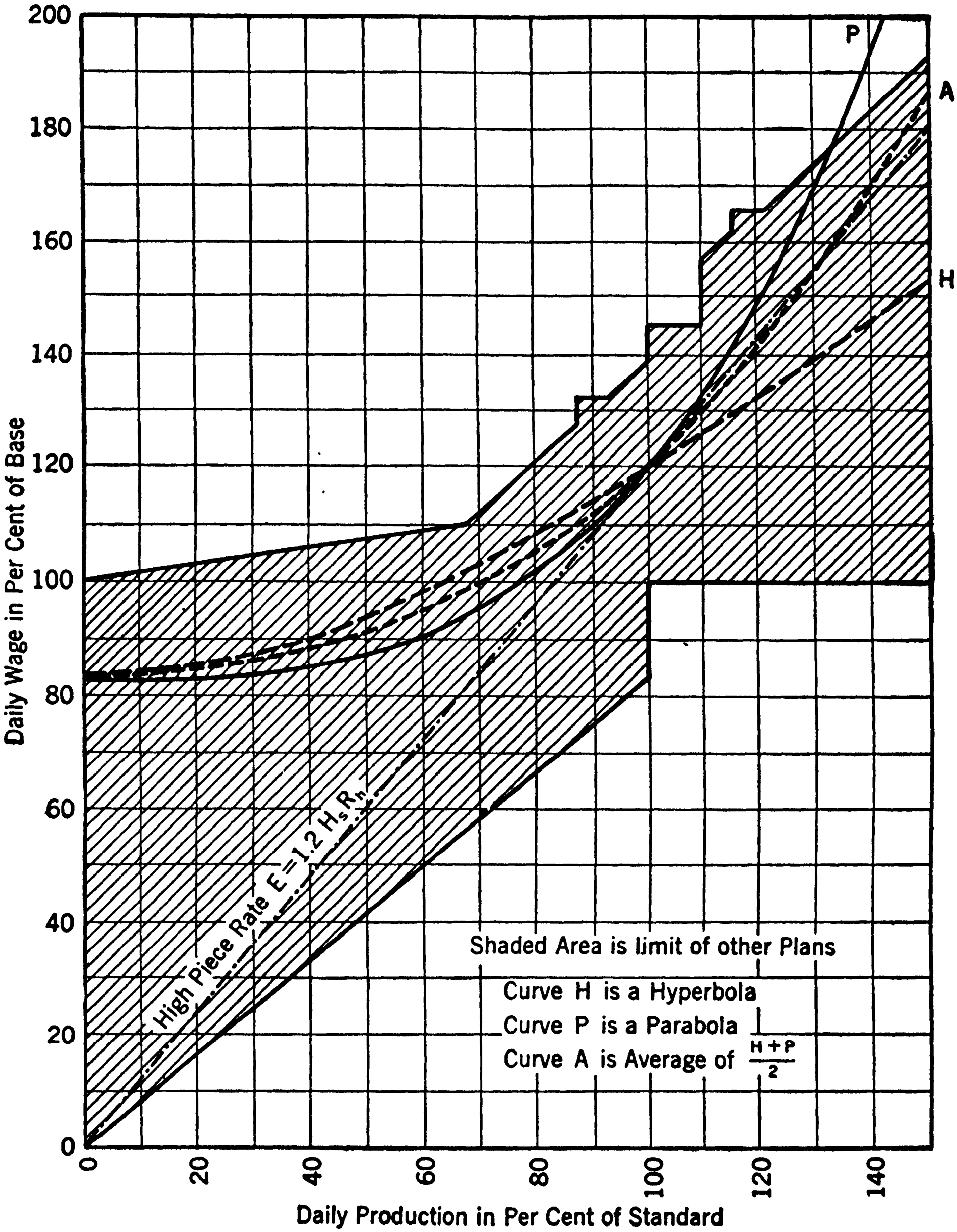


Figure 76. Accelerating Premium Plans in Relation to Other Plans

The first clue to the possibility of these curves came from the chance plotting of an equilateral conjugate hyperbola in a coordinate grid with its asymptote passing through the points of normal piece rate, with the base line X-X' representing the point of no earnings, and the line W-W' representing standard day wages. The result presented an astonishing similarity to those wage payment plans based on a guaranteed daily wage plus a share of the savings over a given task production. Since the equilateral hyperbola has an equation which contains but a single constant for its central axial position, its conjugate could be passed through but a single predetermined point, whether such point be at the apex or on the limb. As the condition of the problem required that the curve be passed through two predetermined points, one at the apex and one on the limb, the retention of the simplicity of expression of the central curve suggested the discarding of the equilateral curve in favor of the variable curve as defined above (equation 1). It is, however, possible to retain the equilateral curve by shifting the horizontal axis, in which circumstance the equation of the curve is defined by the expression,

$$\frac{x^2}{a^2} - \frac{(y-b)^2}{a^2} = -1 \tag{3}$$

This curve develops two constants which permit passing it through two predetermined points. When real values are substituted for the variables, however, and the resulting equations solved for the constants, the constants lose the simplicity they develop in the variable curve. Hence the computations are rather elaborate and have been relegated to Appendix B.

The hyperbola was arbitrarily passed through the high task wage rate point of 120% of standard wages and through successive minimum wage rate points of from 40% to 100% standard wage rate by 20% increments and the results plotted in Figure 79 together with the tangent to the respective curves at the high task wage rate point (100, 120). The notation 60/120 with respect to the curve signifies that it has been passed through a no-task point to give a guaranteed wage rate of 60% standard, and a high task point to give a high wage rate of 120% standard. Other figures indicate a similar situation except for the substitution of the given figures for the two guaranteed wage rates. While this analysis adheres to the standard wage rates for the sake of providing comparisons with other forms of wage payment plans, yet it is possible to consider the formulas to be developed in the relation that one bears to the other without reference to the standard day's wage. That is to say, either the minimum wage can be taken as a ratio of the task wage, or the

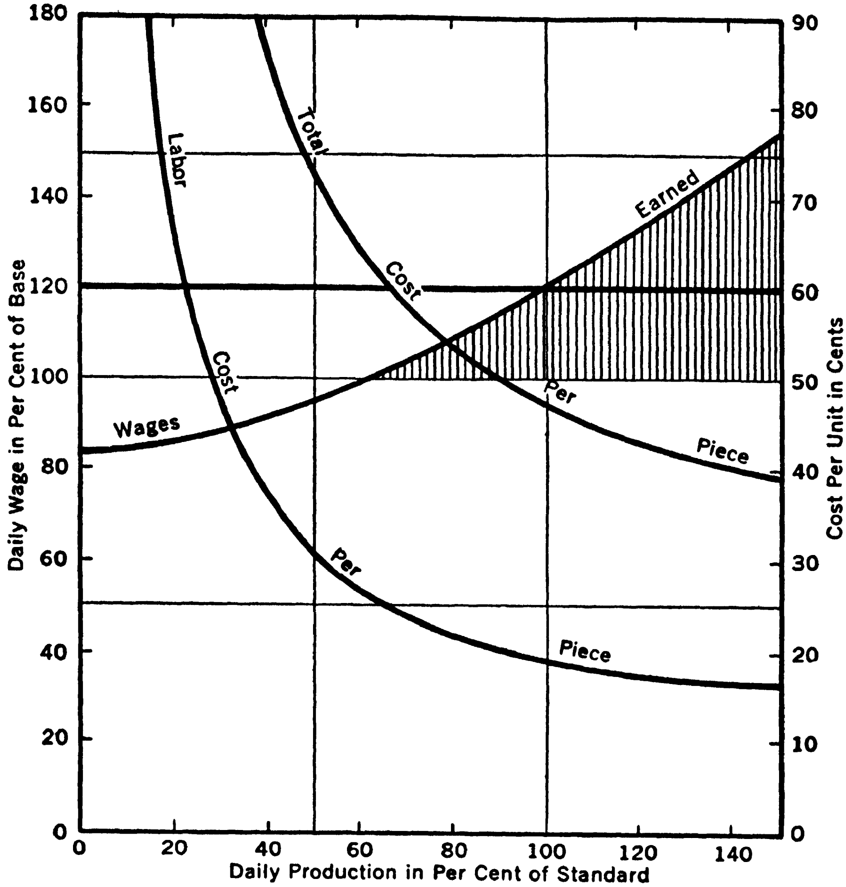


Figure 77. Accelerating Premium (Hyperbolic) Plan, 83⅓% Minimum
(For data see Table 55. The analyzer curves, Figure 78, show how slopes and intercepts change for this earning curve.)

task wage can be taken as a ratio of the minimum wage without the use of the standard wage, in which case one of the rates becomes unity. Since the formulas are to be general this will be ignored.

Accelerating Premium (Hyperbolic) Plan.—In analyzing the hyperbolic curve from the standpoint of a wage payment plan (Figure 77), it is to be observed that some considerable production must be achieved before the total wage rises materially above the guaranteed minimum; then as the curve begins to slope upwards, it crosses the line of standard day's pay at a low task point (100, 64) that corresponds favorably with low task of other plans. Continuing its upward trend it passes through the point of pay for high task to correspond as desired with any particular high task pay point of any other plan. Thence if a tangent to the curve be drawn through this high efficiency-earning point, it is observed that this tangent can be likened to a constant sharing plan for high production. The curve slopes

TABLE 55. ACCELERATING PREMIUM (HYPERBOLIC) DATA, 83⅓% MINIMUM

Per Cent of Production H_s/H_a	Per Cent of Total to Base Wage for Full Day $E/H_a R_h$	Total Daily Wage in Dollars E	Number Pieces per Day	Time Saved per 8-Hr. Task in Hours $H_s - H_a$	Labor Cost per Piece in Dollars	Total Cost per Piece in Dollars
0	83	3.20	0	∞	∞	∞
10	84	3.22	2.4	− 72.0	$1.34	$3.06
20	85	3.27	4.8	− 32.0	.68	1.60
30	87	3.35	7.2	− 18.7	.47	1.12
40	90	3.46	9.6	− 12.0	.36	.88
50	94	3.60	12.0	− 8.0	.30	.74
60	98	3.77	14.4	− 5.3	.26	.65
64	100	3.84	15.4	− 4.5	.25	.62
66	101	3.88	16.0	− 4.0	.24	.61
73	104	4.01	17.5	− 3.0	.23	.57
80	108	4.16	19.2	− 2.0	.22	.54
89	113	4.35	21.4	− 1.0	.20	.50
100	120	4.61	24.0	0.0	.19	.47
114	129	4.95	27.4	1.0	.18	.44
133	142	5.46	32.0	2.0	.17	.41
145	150	5.78	34.8	2.5	.16	.40

See also Table 81 in Appendix B.

away from this tangent in an upward direction, thus indicating that subsequent wage rates are somewhat better than the constant sharing plan symbolized by the tangent. It will also be observed that as the differential between the minimum guaranteed rate and the high task rate becomes greater and greater, the closer the earnings approach those of the usual high piece rate plan, although they never quite reach those rates.

First a computation of the hyperbolic curve will be made in conformity with the requirements of the federal law for an ultimate minimum wage rate of $.40 per hour for an 8-hour day. On the other hand, the standard factors used in this text are to be used in the formation. These provide for: an 8-hour day, an hourly wage rate of $.48, 120% of standard wage at high task, high task at 24 pieces per 8 hours, material cost at $.12 per piece, and overhead at $3.84 per man-day. Under these conditions the minimum wage amounts to 8 × $.40, or $3.20 per day. The standard wage amounts to 8 × $.48, or $3.84. The premium wage amounts to $3.84 × 120%, or $4.61. From this data we determine:

B = $3.20 ÷ $3.84 = .833, and W = $4.61 ÷ $3.84 = 1.20

FORMULA FOR EARNING:

Earning at any efficiency = Rate per Hour × Square Root of Quantity

$$E = R_h \sqrt{W^2 H_s^2 - B^2 (H_s^2 - H_a^2)}$$

or $$E = H_a R_h \sqrt{B^2 + (W^2 - B^2)\left(\frac{H_s}{H_a}\right)^2} \qquad (36)$$

* Derived in Appendix B.

Key to Symbols

E = Earning in dollars (the vertical variable)
H_s = Hours standard (the horizontal variable)
H_a = Hours actual (a constant)
R_h = Rate per hour in dollars (a constant)
B = Ratio of minimum wage rate to basic wage rate, 83⅓% for $.40
W = Ratio of 100% efficiency earning to standard time earning, 120%

Cost per Piece.—The direct labor cost curve, through low efficiency points, behaves much like that of the straight time plan, that is, it is above the range of practicality at first but it comes down rapidly through intermediate efficiencies and is low thereafter. The total cost curve reflects this, high at the left but low by 100% efficiency

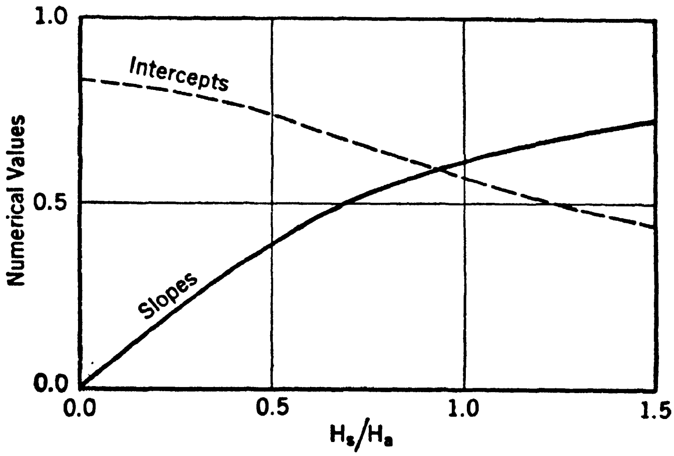


Figure 78. Analyzer Curves for Above Earning Curve

Coefficients for Analyzer

$$E = H_a R_h + (m + b - 1) H_a R_h + m (H_s - H_a) R_h$$
$$E = (m + b) H_a R_h + m (H_s - H_a) R_h$$
$$E = m H_s R_h + b H_a R_h$$

and beyond. Through the effective range 60% to 80% efficiency all characteristics are much like the 50/50 constant sharing plan. The slight acceleration of pay should, however, have a good psychological effect. When lower values are taken for B the hyperbolic earning curves accelerate faster, and when ($B = 40\%$) the earning above high task approaches high piece rate, thus acquiring all the favorable characteristics of that plan plus a practical meeting of the low efficiency legal requirement. For wage rates of $1 or more the

TABLE 56. COEFFICIENTS FOR THE TERMS OF THE HYPERBOLIC ANALYZERS,* 83⅓% BASIS

H_s/H_a	$E=H_aR_h+(m+b-1)H_aR_h+m(H_s-H_a)R_h$			$E=(m+b)H_aR_h+m(H_s-H_a)R_h$		$E=m\ H_s\ R_h+bH_a\ R_h$		$E=y\ H_a\ R_h$
	$H_a R_h$	$(m+b-1)$ $H_a R_h$	m $(H_s-H_a) R_h$	$(m+b)$ $H_a R_h$	m $(H_s-H_a) R_h$	m $H_s R_h$	b $H_a R_h$	y $H_a R_h$
.00	1.0000	−.1667	.0000	.8333	.0000	.0000	.8333	.8333
.10	1.0000	−.0803	.0890	.9197	.0890	.0890	.8289	.8378
.20	1.0000	−.0090	.1750	.9910	.1750	.1750	.8160	.8510
.30	1.0000	.0421	.2563	1.0421	.2563	.2563	.7958	.8727
.40	1.0000	.1006	.3308	1.1006	.3308	.3308	.7698	.9021
.50	1.0000	.1371	.3972	1.1371	.3972	.3972	.7399	.9385
.60	1.0000	.1635	.4558	1.1635	.4558	.4558	.7077	.9812
.64	1.0000	.1718	.4774	1.1718	.4774	.4774	.6944	1.0000
.66	1.0000	.1753	.4874	1.1753	.4874	.4874	.6879	1.0096
.73	1.0000	.1855	.5209	1.1855	.5209	.5209	.6646	1.0449
.80	1.0000	.1926	.5510	1.1926	.5510	.5510	.6416	1.0824
.89	1.0000	.1980	.5846	1.1980	.5846	.5846	.6126	1.1336
1.00	1.0000	.2000	.6213	1.2000	.6213	.6213	.5787	1.2000
1.14	1.0000	.1974	.6589	1.1974	.6589	.6589	.5384	1.2897
1.33	1.0000	.1880	.6993	1.1880	.6993	.6993	.4887	1.4211
1.45	1.0000	.1805	.7188	1.1805	.7188	.7188	.4617	1.5040
1.50	1.0000	.1770	.7261	1.1770	.7261	.7261	.4509	1.5401

* See also Tables 79 and 80 in Appendix B.

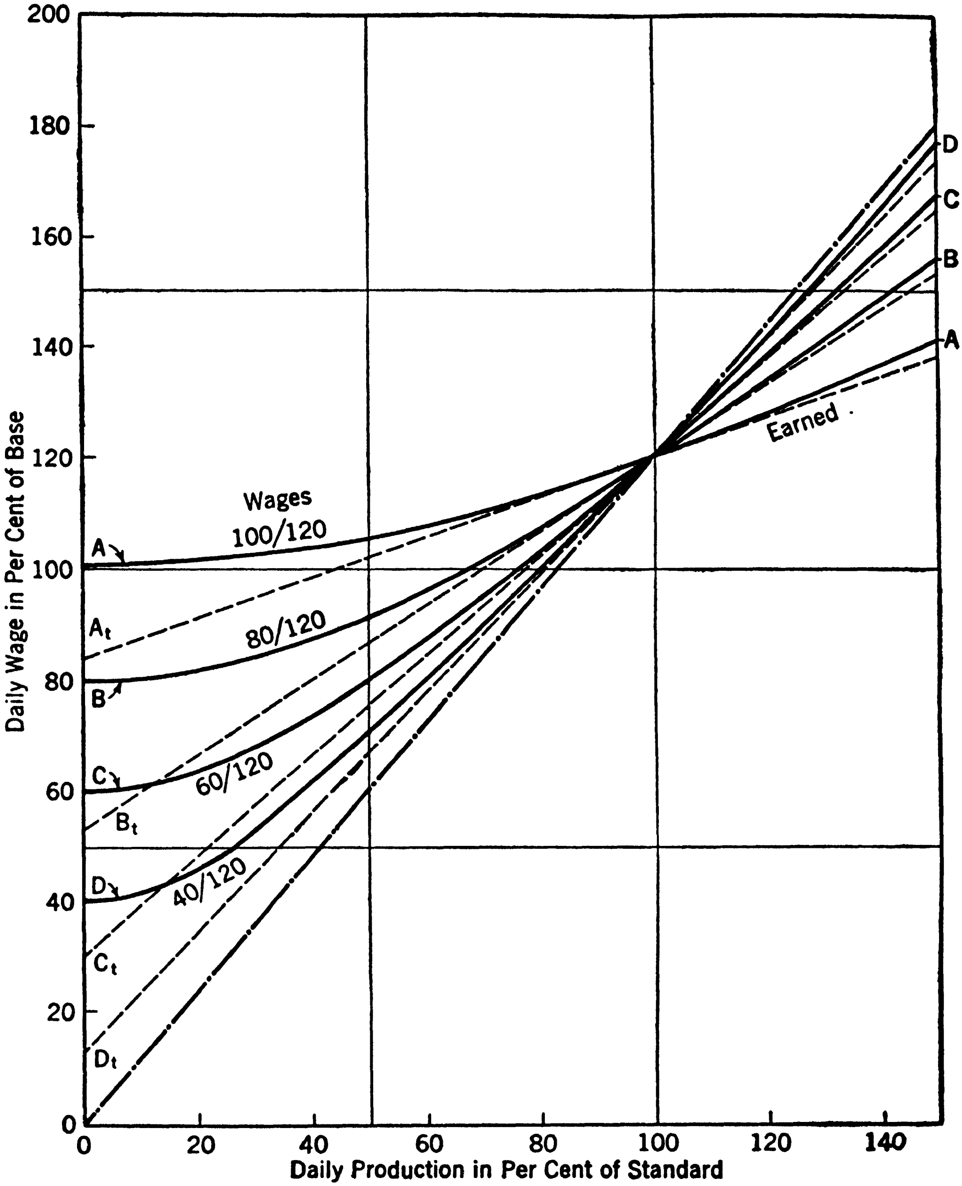


Figure 79. Accelerating Premiums (Hyperbolic) Curves and Tangents to (100, 120)
(See separate curves in Appendix B.)

($B = 40\%$) hyperbola (Figure 79) should give mutual satisfaction wherever high tempo is required, but lack of a step bonus would permit some scattering, hence we do not recommend it for cases involving high machine charges.

Comparison of Hyperbolic Curves.—The algebraic method for the solution of the hyperbolic curve will be used to determine the elements of four typical curves where

1st case	$W = 1.2$ when $B = .4$
2nd case	$W = 1.2$ when $B = .6$
3rd case	$W = 1.2$ when $B = .8$
4th case	$W = 1.2$ when $B = 1.0$

The constants of the table $(W^2 - B^2)$ can be conveniently computed by factoring where $(W^2 - B^2) = (W + B)\ (W - B)$, whence,

1st case	$(1.2 + .4)\ (1.2 - .4) = 1.6 \times .8 = 1.28$
2nd case	$(1.2 + .6)\ (1.2 - .6) = 1.8 \times .6 = 1.08$
3rd case	$(1.2 + .8)\ (1.2 - .8) = 2.0 \times .4 = .80$
4th case	$(1.2 + 1.0)\ (1.2 - 1.0) = 2.2 \times .2 = .44$

which values are entered in their appropriate column. The computations for progression of H_s/H_a from 0 to 1.5 are then made in a routine manner from the procedure adopted. Since it is desired to know at what point H_s/H_a the wage curve crosses the standard wage line $(E/H_a R_h = 1.0)$, the value of $E/H_a R_h = 1$ is inserted at its appropriate place in the table; then by means of the reverse procedure, the corresponding value of H_s/H_a determined. The values of the intercept and slope of the tangent analyzer are then determined according to procedure.

The computations are entered in four respective tables (75-78) and each is accompanied by a pair of charts (Figures 96-103) in which the computed values of,

$$\frac{E}{H_a R_h} \text{ against } \frac{H_s}{H_a}$$

$$b \text{ against } \frac{H_s}{H_a}$$

$$m \text{ against } \frac{H_s}{H_a}$$

are plotted graphically for the determination of intermediate values. At a later point a computation showing the use of the hyperbolic functions has been inserted, but more thereof anon. There follows Figure 79 the computations and graphs of the four hyperbolic curves with their tangents through the high task response point $(E/H_a R_h = W = 1.2$ and $H_s/H_a = 1.0)$ and their intercept point $(E/H_a R_h = A, B, C,$ or D, when $H_s/H_a = 0)$.

Accelerating Premium (Parabolic) Plans.—The parabolic curve suggests itself as a companion to the hyperbola. As indicated by equation (2) the parabolas used are a family of curves of which the conic parabola is but a single curve in an infinite number. By shifting the parabolas upward on their vertical axis a predetermined

distance from the origin, they can be made to conform to three conditions. Hence, the curves can be made to pass through the same two points selected for the hyperbolas and then made to conform to whatever further condition may be selected. Since an increase rate is desired for points above high task, the natural suggestion for the extra condition is to make the curves tangent to the high piece rate line at the high task point.[2] As before, four parabolas have been computed and plotted for the conditions of 40/120 to 100/120 by 20% increments and are shown in Figure 82 together with their common tangent at the high task, high wage rate point. Their correspondence with the desired properties is quite obvious.

Conclusions Drawn From Mathematics.—The mathematical detail for these plans is complex and was originally done in conventional symbols *x*, *y*, etc., and then translated into the standard wage incentive symbols. The final equations only will be given in this chapter. Of numerous possible variations we have shown one on the points (0, 83⅓) and (100, 120) (Figure 80). Analyzer curves are given in Figure 81. Note that the premium can be made to accelerate more rapidly by the use of these curves than by the hyperbolas, in fact all of these diverge above the high piece rate line. Hence these curves can be used to follow piece rates without any objection from employees. Parabola II has a generous earning curve, but it is not at all impractical if high efficiencies are really desired.

FORMULA FOR EARNING:

Earning at any efficiency = Rate per Hour × Square Root of Quantity

$$E = B\,H_a\,R_h + \frac{(W - B)\,H_s{}^n\,R_h}{H_a{}^{(n-1)}} \qquad (74)^*$$

* Derived in Appendix B.

Key to Symbols

E = Earning in dollars (the vertical variable)
H_s = Hours standard (the horizontal variable)
H_a = Hours actual (a constant)
R_h = Rate per hour in dollars (a constant)
B = Ratio of minimum wage rate to basic wage rate, 83⅓% for \$.40
W = Ratio of 100% efficiency earning to standard time earning, 120%

$$N = \frac{W}{W - B}.$$ See Appendix B (62).

[2] A coal mining company has recently adopted parabolic curves with a cost-efficiency task. For secondary supervisors premiums begin at 70% of task and reach 120% of base at 100% task. For first line supervisors premiums begin at 83% and reach 140% of base at 100%.

Cost per Piece.—At the low efficiency end the cost curves are high as in the hyperbolic plan (Figure 77) then running slightly lower than in that plan to 100% efficiency. Thereafter the costs run higher in these parabolic plans. As always this should be set against the likelihood of attainment. Highest efficiencies can hardly be expected under the hyperbolic plans, except perhaps under the special one where $B = 40\%$ (Figure 96). In the parabolic plans highest efficiencies can be attained, in fact, the one in which $B = 100\%$ (Figure

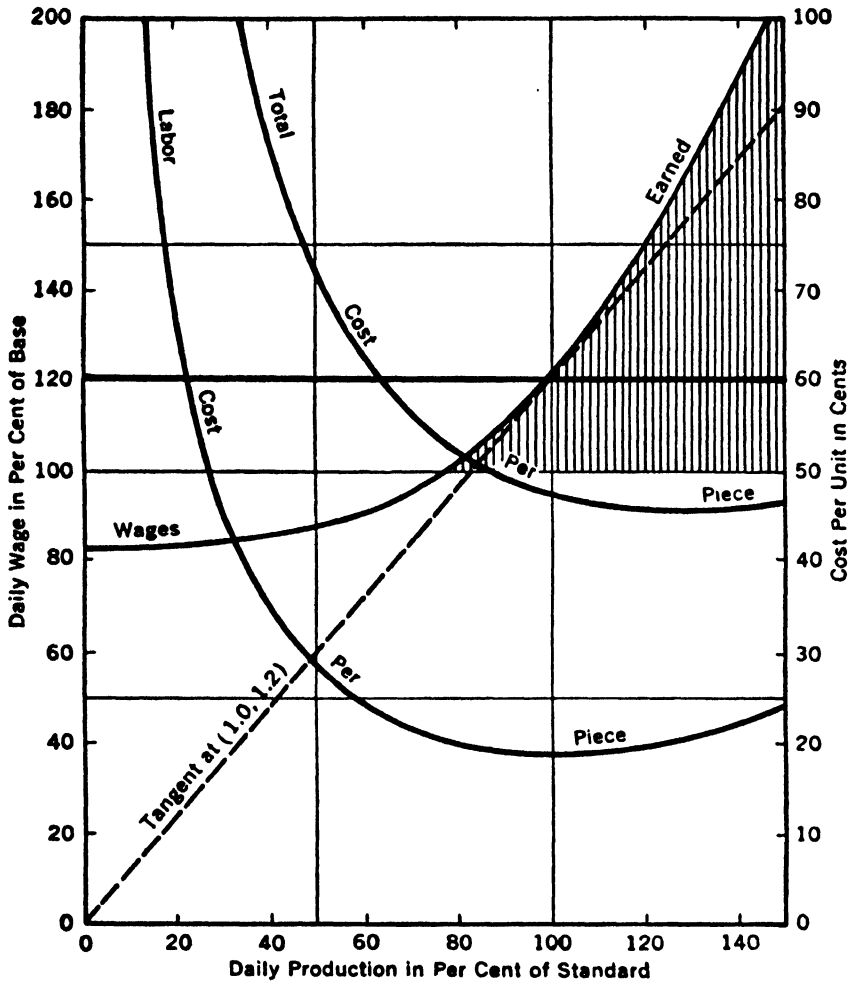


Figure 80. Accelerating Premium (Parabolic) Plan 83⅓% Minimum
(For data see Table 57.)

111) is the most generous incentive ever proposed. If an increasing total cost[3] is not justified by the conditions, then the hyperbolic plan (Figure 96), in which $B = 40\%$, should be adopted. The earning curves for the parabolic plans shown in this chapter are close to that

[3] On account of scattering it is likely that the total cost would remain about constant and slightly above the low point shown in the chart. See note to Figure 19.

of high piece rate but diverge slightly above it and above task all the characteristics approximate those of that plan. With these above task merits together with a solution of the minimum requirement, the parabola, properly fitted, is ideal for many modern situations, the $B = 100\%$ for supervisors and executives.

TABLE 57. ACCELERATING PREMIUM (PARABOLIC) DATA, 83⅓% MINIMUM

Per Cent of Production H_s/H_a	Per Cent of Total to Base Wage for Full Day $E/H_a R_h$	Total Daily Wage in Dollars E	Number Pieces per Day	Time Saved per 8-Hr. Task in Hours $H_s - H_a$	Labor Cost per Piece in Dollars	Total Cost per Piece in Dollars
0	83	3.20	.0	∞	∞	∞
10	83	3.20	2.4	− 72.0	$1.33	$3.05
20	83	3.21	4.8	− 32.0	.67	1.59
30	84	3.23	7.2	− 18.6	.45	1.10
40	85	3.27	9.6	− 12.0	.34	.86
50	87	3.34	12.0	− 8.0	.28	.72
60	90	3.46	14.4	− 5.3	.24	.63
66	92	3.56	16.0	− 4.1	.23	.59
73	96	3.70	17.5	− 3.0	.21	.55
79	100	3.84	18.9	− 2.1	.20	.53
80	101	3.88	19.2	− 2.0	.20	.52
89	108	4.16	21.4	1.0	.19	.49
100	120	4.61	24.0	0.0	.19	.47
114	139	5.36	27.4	1.0	.20	.46
133	207	6.78	32.0	2.0	.21	.45
145	221	7.95	34.8	2.5	.23	.46

See also Table 88 in Appendix B.

Comparison of Parabolic Curves.—The procedure for the solution of the parabolic curves was adopted because of its brevity. It does not facilitate columnar computations of x when y is given, but does permit such computations when a simple external computation is first made. As in the case of the hyperbola, the elements of the parabolic curve will be computed for the same four cases where:

1st case $W = 1.2$ when $B = .4$
2nd case $W = 1.2$ when $B = .6$
3rd case $W = 1.2$ when $B = .8$
4th case $W = 1.2$ when $B = 1.0$

The only constant to be computed is the power of the various curve equations. This is denoted by, $n = \frac{W}{W-B}$ (62)

and resolves itself into,

1st case $n = (1.2) \div (1.2 - .4) = 1.2 \div .8 = 1.5$
2nd case $n = (1.2) \div (1.2 - .6) = 1.2 \div .6 = 2.0$
3rd case $n = (1.2) \div (1.2 - .8) = 1.2 \div .4 = 3.0$
4th case $n = (1.2) \div (1.2 - 1.0) = 1.2 \div .2 = 6.0$

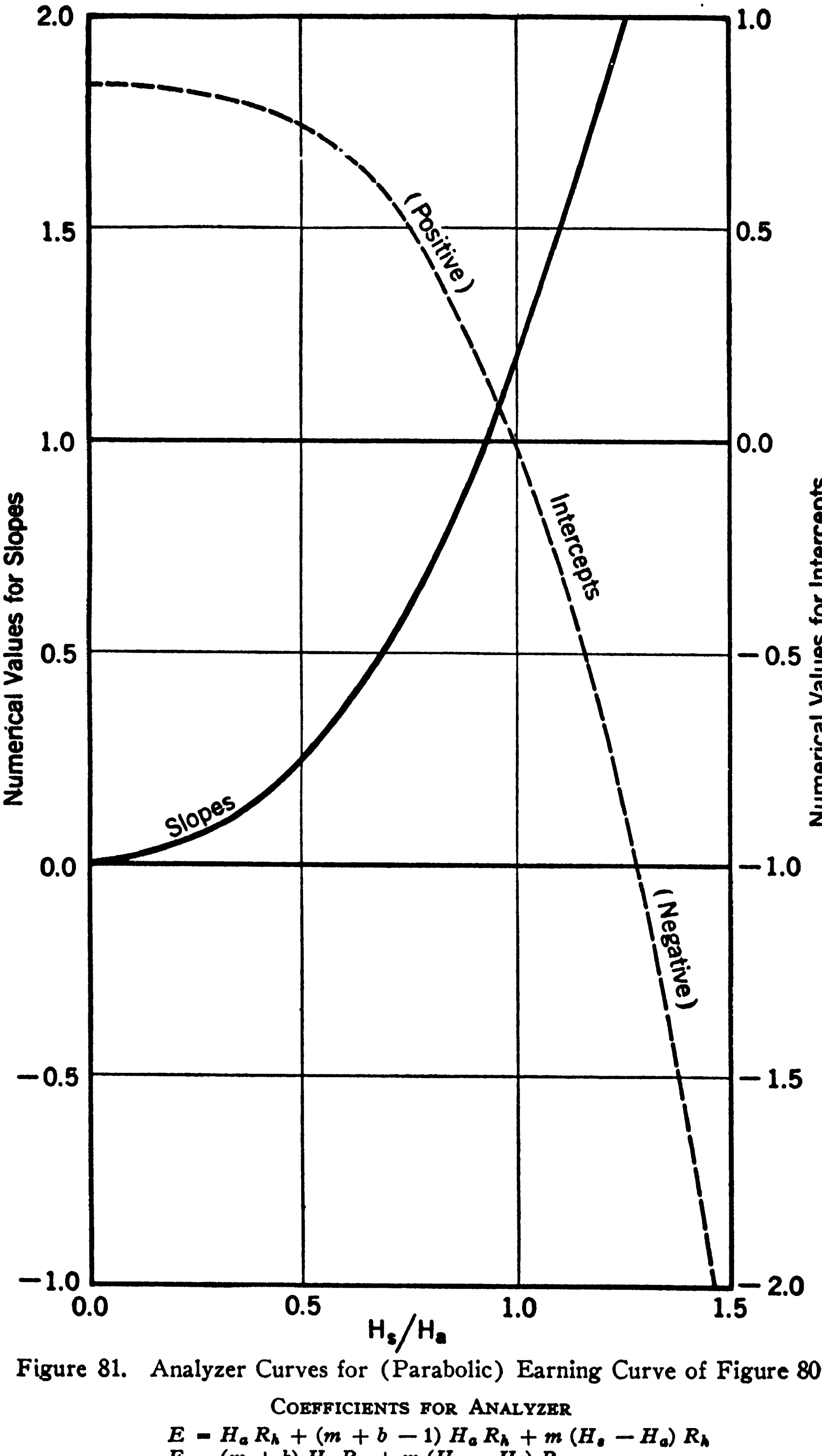


Figure 81. Analyzer Curves for (Parabolic) Earning Curve of Figure 80

COEFFICIENTS FOR ANALYZER

$$E = H_a R_h + (m + b - 1) H_a R_h + m (H_s - H_a) R_h$$
$$E = (m + b) H_a R_h + m (H_s - H_a) R\cdot$$
$$E = m H_s R_h + b \, . \, H_a R_h$$

TABLE 58. COEFFICIENTS FOR THE TERMS OF THE PARABOLIC ANALYZERS,* 83⅓% BASIS

H_s/H_a	$E=H_aR_h+(m+b-1)H_aR_h+m(H_s-H_a)R_h$			$E=(m+b)H_aR_h+m(H_s-H_a)R_h$		$E=mH_sR_h+bH_aR_h$		$E=yH_aR_h$
	H_aR_h	$(m+b-1)$ H_aR_h	m $(H_s-H_a)R_h$	$(m+b)$ H_aR_h	m $(H_s-H_a)R_h$	m H_sR_h	b H_aR_h	y H_aR_h
.0	1.0000	−.1667	.0000	.8333	.0000	.0000	.8333	.8333
.10	1.0000	−.1611	.0060	.8389	.0060	.0060	.8329	.8335
.20	1.0000	−.1400	.0310	.8600	.0310	.0310	.8290	.8352
.30	1.0000	−.1058	.0770	.8942	.0770	.0770	.8172	.8405
.40	1.0000	−.0581	.1490	.9409	.1490	.1490	.7919	.8515
.50	1.0000	−.0055	.2484	.9945	.2484	.2484	.7461	.8703
.60	1.0000	.0515	.3758	1.0515	.3758	.3758	.6757	.9012
.66	1.0000	.0859	.4661	1.0859	.4661	.4661	.6198	.9274
.73	1.0000	.1226	.5868	1.1226	.5868	.5868	.5358	.9642
.79	1.0000	.1449	.6904	1.1449	.6904	.6904	.4545	1.0000
.80	1.0000	.1546	.7228	1.1546	.7228	.7228	.4318	1.0100
.89	1.0000	.1851	.9208	1.1851	.9208	.9208	.2643	1.0838
1.00	1.0000	.2000	1.2000	1.2000	1.2000	1.2000	.0000	1.2000
1.14	1.0000	.1700	1.6162	1.1700	1.6162	1.6162	− .4462	1.3963
1.33	1.0000	.0086	2.2944	1.0086	2.2944	2.2944	−1.2858	1.7657
1.45	1.0000	−.1861	2.7921	.8139	2.7921	2.7921	−1.9782	2.0704
1.50	1.0000	−.2923	3.0156	.7077	3.0156	3.0156	−2.3079	2.2155

* See also Tables 87 and 88 in Appendix B.

These values for n are entered in the appropriate column and the routine procedure followed for the computation of the desired elements. In the cases noted, computations can be facilitated by the use of square and cube tables, that is, the values of x^n in the second and third cases can be taken directly from the tables. The first case is obtained by taking square root values of the third case and the fourth case by taking cubes of the second case.

The reverse values of x are computed from the formula,

$$x^n = \frac{Y - B}{W - B} \tag{70a}$$

for each case. Since in our immediate problems, it is only desired to determine x when $y = 1$, the computations resolve themselves into the simple following set:

1st case	$x^n = (1 - .4) \div (1.2 - .4) = .6 \div .8 = .75$
2nd case	$x^n = (1 - .6) \div (1.2 - .6) = .4 \div .6 = .67$
3rd case	$x^n = (1 - .8) \div (1.2 - .8) = .2 \div .4 = .50$
4th case	$x^n = (1 - 1.0) \div (1.2 - 1.2) = .0 \div .2 = .00$

These values are then entered in column E which is the column set apart for x^n. Reversed computations give the abscissa x corresponding to a unit ordinate while routine computations from x^n forward provide the other elements. The computations are entered in four respective Tables 83 to 86, and each set is accompanied by a pair of charts (Figures 105-112) in which the computed values of

$$\frac{E}{H_a R_h} \text{ against } \frac{H_s}{H_a}$$

$$b \text{ against } \frac{H_s}{H_a}$$

$$m \text{ against } \frac{H_s}{H_a}$$

are plotted graphically for the computed values in Figure 82.

Variety of Same Type Curves Convenient.—A family of related earning curves may have several advantages. Different sets of conditions in a single plant can be met by a single kind of plan. A single percentage of earning at task tends to unify payment policy provided the controls, training, etc., are good enough to allow average response to center around the task efficiency. We do not believe, however, that this focusing at a standard earning can ever be close enough, without step bonuses, to keep the labor cost fixed at

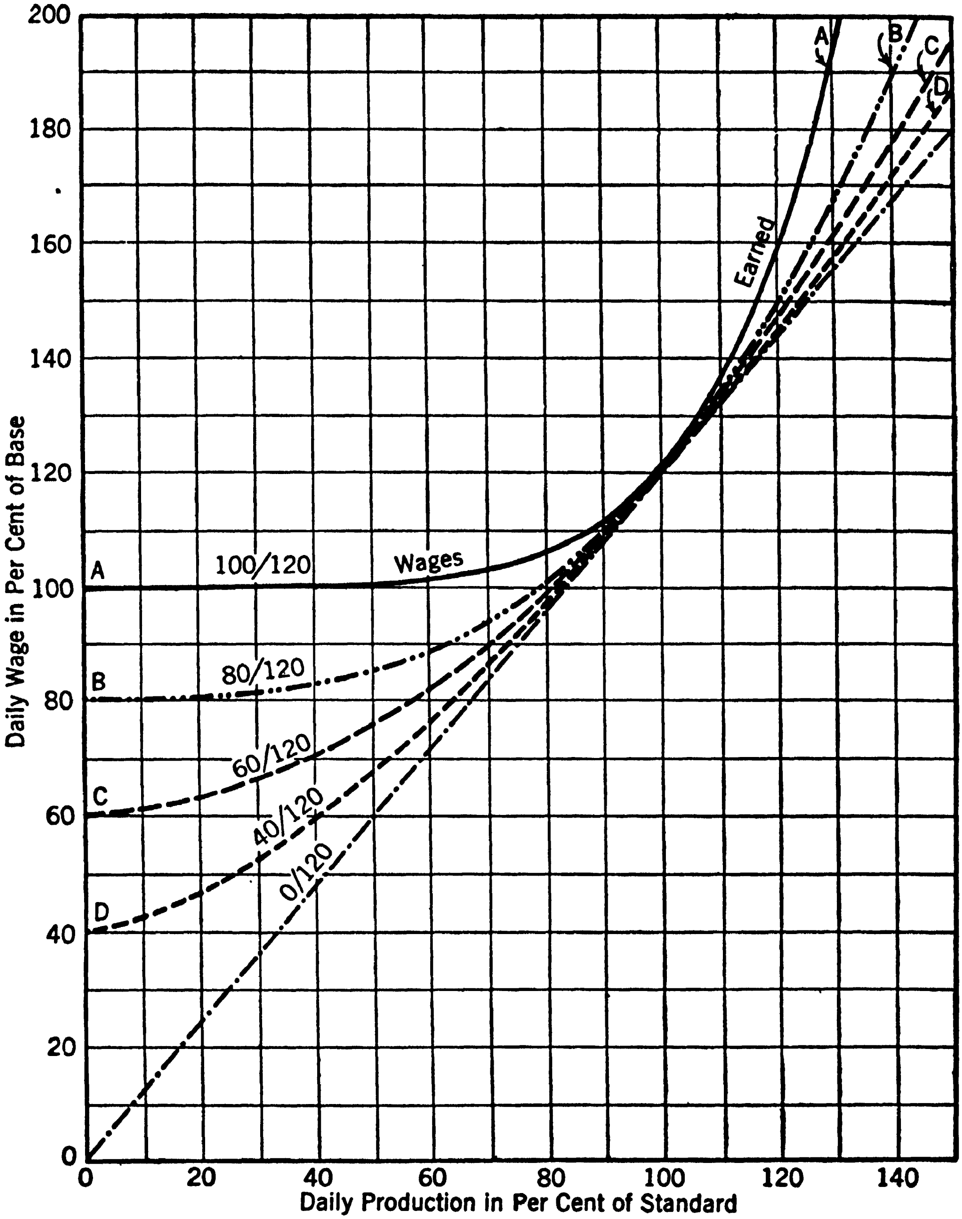


Figure 82. Accelerating Premium (Parabolic) Curves and Tangent to 100, 120
(See separate curves in Appendix B.)

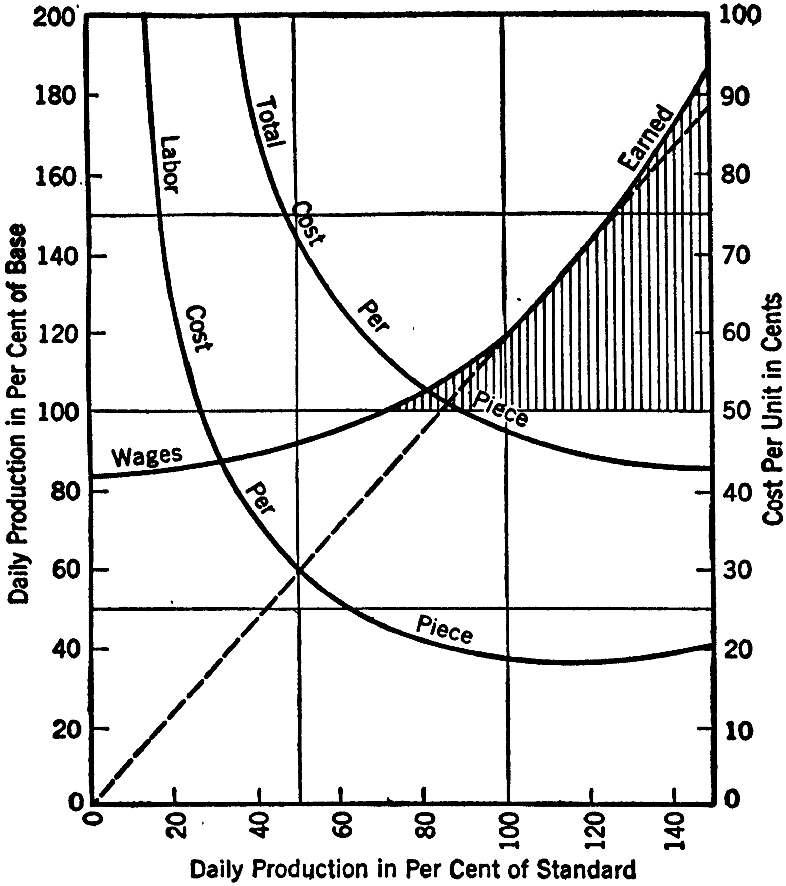


Figure 83. Accelerating Premium (Hybrid of Hyperbolic and Parabolic) Plan

TABLE 59. ACCELERATING PREMIUM (HYBRID H. & P.) PLAN, 83⅓% MINIMUM

Per Cent of Production H_s/H_a	Per Cent of Total to Base Wage for Full Day $E/H_a R_h$	Total Daily Wage in Dollars E	Number Pieces per Day	Time Saved per 8-Hr. Task in Hours $H_s - H_a$	Labor Cost per Piece in Dollars	Total Cost per Piece in Dollars
0	83	3.20	0	∞	∞	∞
10	83	3.21	2.4	− 72.0	1.34	3.06
20	84	3.24	4.8	− 32.0	.68	1.60
30	85	3.29	7.2	− 18.6	.46	1.11
40	87	3.37	9.6	− 12.0	.35	.89
50	90	3.47	12.0	− 8.0	.29	.73
60	94	3.61	14.4	− 5.3	.25	.64
66	96	3.72	16.0	− 4.0	.24	.60
72	100	3.84	17.4	− 3.0	.22	.56
73	100	3.86	17.5	− 3.0	.22	.56
80	104	4.02	19.2	− 2.0	.21	.53
89	110	4.26	21.4	− 1.0	.20	.50
100	120	4.61	24.0	0.0	.19	.47
114	134	5.16	27.4	1.0	.19	.45
133	159	6.11	32.0	2.0	.19	.43
145	178	6.86	34.8	2.5	.20	.43

standard. At least these accelerating parabolas can provide consistent earnings both sides of the task efficiency whereas any family of hyperbolas or straight lines must cross and make inconsistencies, as brought out in Figures 79 and 52.

Accelerating Premium (Hybrid H. & P.) Plan.—Since the hyperbolic plans lie slightly below, and the parabolic plans lie slightly above high piece rate beyond point (100, 120), it is possible to derive an accelerating premium plan which will approximate high piece rate by taking the arithmetic averages of an hyperbola and a parabola. Figure 83 shows such a plan. Notice that right beyond point (100, 120) this earning curve runs below that of piece rate and thereafter above that line but not far from it. We have then a plan that starts at the legal minimum, accelerates fast through intermediate efficiencies to the task-earning point, and approximates high piece rate thereafter, terminating in a generous slope but without raising the total cost as is done by the parabolic plan. This hybrid plan thus combines most of the advantages of other accelerating plans and can replace any piece rate plan without radical change. We recommend it for any conditions where high piece rate, with or without time guarantee, was satisfactory before there was any legal requirement regarding the minimum rate. For comparisons see Figure 32.

CHAPTER 16

GROUP APPLICATIONS OF INCENTIVE PLANS

The spirit of teamwork is capitalized in group work.—H. S. PERKINS.

The Same Plans but Differently Applied.—Writers on group incentive plans frequently fail to show which of the earning curves are used. Wennerlund and piece rate with day guarantee are the plans most commonly used, but nearly all of the other individual plans are also widely used. The collective feature alone is common to all. Collective piece work[1] has been used in English dockyards and flint glass trades for over fifty years. Gang piece work, as it is called in the United States, and the various group bonus applications did not come into extensive use, until after 1917. It then became popular first, as a means of securing cooperation without expensive supervision and, second, as a means of simplifying job standardization and clerical work in large companies.

Mass production with its continuous flow of work extends the subdivision of operations and makes sequential synchronization the major consideration. Each operator becomes dependent upon all earlier operators in his sequence. Thus in chain assembly and any similar work, the balance of execution and the steadiness of flow are more important than maximum individual production. An incentive plan for such work must reflect these needs. In a baseball game a sacrifice is as important as a star play. In group work, individual starring would even be detrimental but as a matter of fact it cannot occur, except momentarily, because an ambitious individualist would run himself out of parts to work upon.

Definition of Group Incentive.—We may now define the group incentive as any incentive applied collectively to employees whose operations are definitely interdependent or related, and who are equally suited to their various duties. Such a group, even if fairly large, will have community of interest and mutual respect of individual members. If either of these two elements is lacking, the group will be inharmonious, no matter how small. The amount of production is measured as it passes inspection upon leaving the group. Only one

[1] D. F. Schloss, *Methods of Industrial Remuneration*, 1892.

job ticket is needed, as the net efficiency of the group is usually taken as the efficiency of individuals. Each individual's time rate may be different and his incentive equal or the latter may depend on the former. It is sometimes possible to have both the day rate and the incentive identical for all members. More often, some skilled and some unskilled individuals are necessary to do the group job. Therefore, it is just for both the time rate and the incentive to be allocated proportionally to the class of skill contributed by individuals.

Leadership Most Important.—The first and most difficult essential of this practice is leadership. A group leader may set a high pace for all members and keep them harmonious or he may do the reverse. Either an extremely aggressive or an extremely popular leader may make trouble. A great deal depends on the coaching given these leaders. If they are expected to eliminate the less efficient individuals without training, or if they are allowed to pick favorites for their groups, there is likely to be constant irritation. When a leader is well selected, trained, and supported, there is likely to be less trouble than under an individual plan. Some claim that the elimination of one or more of the group members by the group as a whole is an important feature of the practice. We think that elimination should be done directly by the management regardless of the incentive application, but if it can be done by the employees in cases almost impossible to the management, then the smaller group is more effective than the large one. The elimination of one from a group of twenty-five leaves only a 4.16% saving for each of the remaining twenty-four. The elimination of one from a group of six leaves a 20% saving for each of the remaining five, so that they are more likely to carry it out. In the case of tardiness or absence of an individual, the rest of the group try to keep up the work. The absentee forfeits his pay which is distributed to the others of the group. One company forbids an employee to return to his group if absent three days. Many groups are as large as 125, although on the average less than twenty. One company states that its experience puts the limit at twelve men. The trouble with a large group is the physical inability of a leader to exert the desired influence when his group members are great distances apart. It is hard enough to find wage employees capable of leading small groups but much harder to find them for large groups. We do not venture to set any limit on the correct size of a group. The principles we have outlined should indicate the limits when applied to specific cases.

Group Applications Should Not Be Made Indiscriminately.—Group application is only suitable for employees on interdependent

operations. Philosophically, it runs counter to reward on individual merit and tends toward mediocrity. It is a leveling between the best and the poorest, neither one getting justice. At its worst, it approaches unstandardized and foreman-driven work. At its best, it can secure a high degree of mutual understanding and cooperation.

Wages tend to be more constant than on the individual basis. If it is used as specified above and not as a camouflage for managerial laziness, it can decrease inspection, scrap, supervision, paper work, and other factory overhead. Clerical work alone has been reduced 60% in some cases. As these reductions are of importance today, management may well afford to take the necessary pains. It should never try to avoid both the detail of an individual plan and the general care known to be vital to the group application, and it should not make the elimination of clerical work the major consideration. The major consideration should be the degree of cooperation desired and whether or not maximum individual productions should be sacrificed to the procurement of better synchronization.

Possibilities of the Plan.—Since a group task may be internally rearranged, group incentives are adapted to take care of maintenance gangs and others on indirect production, that is, work where the individual's share cannot be determined, but it also provides an excellent means of including many of such employees with production groups. Truckers, elevator men, set-up men, as well as repair men, and even sweepers concerned with a unit, may be included in the group and treated as direct producers. A defective part from a previous operation is sure to be stopped before having additional labor put on it. A motor car company claimed in 1923 that the group plan was saving $60,000 a year on scrap alone and $45,000 on inspection, while the average hourly earnings went from $.69 at the installation of the plan to $.80 after two years. They used the Wennerlund scale which amounts to a high piece rate above task.

Plan Is Necessary in Large Concerns.—The magnitude of present-day concerns is giving great impetus to the group idea. For example, one of our largest companies in its two main plants combined, has 40,000 employees on the payroll, and 110,000 separate piece parts to control. It is considered sufficient to time-study a group job such as a subassembly rather than each individual suboperation. About 60% of the employees are on the group basis, not because this company considers the group method ideal, but because it seems necessary. It uses piece rates with guaranteed day wages, and figures efficiencies monthly. In order that the employee may have about the same earning each week, the management pays him a little less

than average past earnings for the first three weeks of the month and makes up any extra amount coming to him the fourth week. The company claims that the single work ticket to a group means a single calculation and thereby simplifies payroll procedure, and that a nearly uniform earning is a result of this plan. The company finds that it pays to keep individual efficiency records and to grade all employees according to a standard A, B, C classification.

Production Records May be Used as Nonfinancial Incentives.—While these efficiencies are usually the same for each man in a group per day, they can, if posted, be compared with efficiencies of other group individuals and are thereby effective as nonfinancial incentives. Where the work of a group is not in a true sequence, that is, when more than one individual does the same subdivision to balance adjacent subdivisions, the individual efficiency will vary. It should then be recorded separately. This type of group gives the most trouble. Beginners may be trained apart so that they need not hold back mature members of any group. Sometimes the group is put on time rates while a beginner is being trained. All individuals should at least be furnished earning scales so they may figure the possible results.

Cautions from Industrialists.—E. E. Brinkman, of the Holeproof Hosiery Company, says:

"Where possible, we employ the individual plan, and only when the efforts of individuals cannot be accurately and easily identified, do we employ the group plan.

"~~Also, where~~ we find it advantageous for one man to help another, and thereby reduce the total men for a given amount of work, we use the group plan. In this case we make it a point to explain to the men that they may earn a premium by devoting all their spare moments to helping their fellow workers."[2]

C. M. Bigelow, of Bigelow, Kent, Willard and Company, says:

"Group rates should be used, only when the proper background of past performance is available, preferably the results of individual rates. As a first application of incentives to a plant, they are seldom advisable."[3]

R. C. Gifford, Automatic Electric Company, says:

"We use the group time plan only where the individual plan is impractical. . . . We do have a few cases where an individual in-

[2] A. M. A. Production Series No. 23.
[3] A. M. A. *Management Review*, Vol. XVII, No. 9.

centive plan might be equally well applied, but where there would be no particular advantage to the company and the group plan does give us the advantage of decreased operating cost so far as the bonus plan is concerned.

"As an example of this we have the progressive assembly line. Each operation is so carefully timed that each employee in the group who is working at average efficiency will be kept normally busy. He can do neither more nor less than his share of the group task. Here we use the group plan.

"Another case in point is one in which the group as a whole contributes to the output, but where the individual effort cannot be measured. Enamelled wire insulating machines would be an example of this, where we have men operating a group of thirty or forty machines, the group working on all machines, and of course, here it would be impossible to measure the individual effort.

"It has been our experience that where practical the individual plan is much better since it offers an incentive to the individual to put forth his best effort without regard to what others are doing."

A Group Standard Hour Plan.—That incentives are more widely extended by the group application is evidenced by an automobile manufacturing company which reports 90% of its 10,000 employees on group incentives. A time study department determines a task for standard time for each unit of work. Jobs are grouped on the basis of community of interest, the efficiency of each group is measured relative to the standard time for the group, and all of the members are paid for all the time saved.

Performance reports issued daily and summarized weekly carry efficiency figures representing the comparative performances of the groups in relation to the standard performances. A group operating at 75% efficiency is doing only three-quarters of the amount of work required to equal standard performance, and a group operating at 150% efficiency is exceeding the standard by one-half. A very low or a very high efficiency indicates the presence of conditions that should be immediately investigated. The weekly report also carries the day rate of pay, the actual earned rate, the number of men in the group, and the amount of allowances, if any, that have been granted by the foreman to compensate for the presence of irregular conditions and unusual manufacturing difficulties. The busy executive, after a few moments' study of these reports, is able to secure a definite picture of the performance of his whole organization.

Specifications for a Group Application.—The whole plan is formulated and operated according to the following specifications:[4]

1. Individuals can be grouped successfully only when they have a community interest in the result of their combined efforts.
2. Individual interest in individual accomplishment must be retained, the success of the group being based on individual incentive and ambition.
3. The group must receive all the directly increased wages accruing from increased production.
4. The plan used must be sufficiently simple to be understood by the workmen.
5. There must be confidence in the management, induced by the square deal.
6. The supervisory and operating personnel must believe in the group idea.
7. The system should be installed by thoroughly competent specialists, who are familiar with the functions of the time, cost, inspection, planning and shop departments.
8. There must be a just distribution of group earnings to the individuals of the group.

The last named of these principles requires a routine sufficiently flexible to operate successfully when recognition is given to the following variables:

1. Different degrees of skill and ability are required on different operations within the group.
2. Different degrees of skill and ability will be found in different employees engaged on the same or parallel operations within the group.
3. Veteran employees are entitled to more consideration than are newcomers.

How Groups Are Formed.—A group of men making brake bands would have about four employees; a group of men on the final assembly line might include sixty men. The final assembly line is broken into about five groups—the frame group, the chassis group, the body assembly and the final assembly, and final inspection.

The earned rate per hour is not limited. A committee, composed of the employment supervisor, time study chief, production manager, and the industrial engineer draws up a classification of rates.

[4] A. M. A. Production Executive Series No. 16.

Each individual in the group gets an individual base rate. Since the rates for individuals in a group are not necessarily the same the total earnings are the base wages of the individual, plus his earned incentive. The total pay checks for all the individuals in the group are divided by the number of pieces made to derive the unit cost.

Saving in Direct Labor Given to Employees.—Groups have reduced the number of men employed in securing a given production, but as standards have been set fairly close the number of men in any given group has not been decreased to the extent of making wages excessive. For instance, a group making differential cases, reduced from eleven to eight men; that increased wages from about $.66 an hour to $.88 or $.90 an hour, which is considered a fair return for those employees.

Reductions have probably ranged from 12% to, in some cases, 35%, but the company has paid the men as increased wages all that has accrued from such reduction. The management has been satisfied to take the saving which it received from increased production per machine hour, with a lower burden rate.

Plan Includes More Than Single-Purpose Departments.—Not only single-purpose departments but such departments as the wood mill, automatics, heat treating, and enameling have been put on this basis. In fact, departments having a varied product are said by this company to be the most fertile fields for elimination of expense and inaccuracy and an increase in productive efficiency ranging from 12% to 35% has been achieved. Wages have been raised so that those not on the plan have taken the initiative in asking to be put on the plan.

Advantages Claimed Over Individual Incentive.—

1. The range of interest is widened so that idle time is turned to mutual benefit. Choke point emergencies are voluntarily met and tool difficulties are more quickly removed.

2. So many time-saving possibilities are presented for which the management is due credit that no difficulty arises in changing tasks and rates at the expiration of the guarantee period.

3. Savings in direct labor costs amounting to several hundred thousand dollars annually have come out of the group feature.

4. Production counts have been more accurate and less expensive, the latter amounting to many thousands of dollars.

5. More definite responsibility has been possible in the matter of scrap and the reduction of defective parts.

Group Piece Rate Plan with Day Guarantee.—A company engaged in vitreous enameling or the making of "frit" and embracing such processes as smelting, ball-milling, pickling, dipping, spraying, wiping, drying, burning, and transferring uses the "Manchester" plan for groups. These groups are formed in clerical departments, storerooms, receiving and shipping departments, toolrooms, inspection work, engineering, and maintenance work as well as in manufacturing departments. Tasks are set by the usual job standardization but in the unusual terms of square feet of surface finished. Time allowances for unavoidable scrap are, of course, added to the ideal standards and lots of small units which require disproportionate handling are balanced by lots of large units. Under job shop conditions, it is necessary to have five, six, or possibly more classification allowances, for example: 150 hours per 1,000 square feet for flat pieces with no wiping; 165 hours per 1,000 square feet for formed pieces that require wiping; 200 hours per 1,000 square feet for cylindrical shaped pieces; etc.

The plan also carries a bonus for the foremen. This is based on the total cost of production to discourage increased production which might be obtained through increased costs.

Claims for Plan.—

1. The group application tends to make thinkers of the employees as they are more alert to suggest changes in dies, fixtures, and even design of parts. Efficient group members are also more ready to transmit their methods to the less capable.

2. Indirect labor: sweepers, truckers, oilers, and die-setters are always interested in seeing that everything is done to keep the operators busy, such as making sure that materials are at hand when required, equipment is kept in running condition, and parts and scrap are moved away from the machines as often as necessary to avoid interfering with the operators' movements. Thus cooperation is increased and supervision decreased.

3. By converting all orders received to standard units, the foremen are able to estimate man-hours required for a given schedule. This lets them plan their work far enough ahead to prevent sharp reductions or increases in labor, which at all times are costly. It also shows the foreman whether or not promises made can be kept. Costs can be easily predetermined and more easily controlled.

4. The plan is cheaper to operate than the individual "Manchester" plan and the unit costs as shown in Figure 84 were greatly reduced during the first few years after the change was made.

Ton-Hour Standard, Adjusted Monthly for Group Piece Work.—The Priestman plan, as it is called, shows the influence of both the group incentive and the sliding scale principle. It has been in operation in English foundries for twenty-four years. A production standard for a whole plant is set each month in terms of ton-hours. If at the end of a month the production has exceeded the standard, each employee, including administrative and office

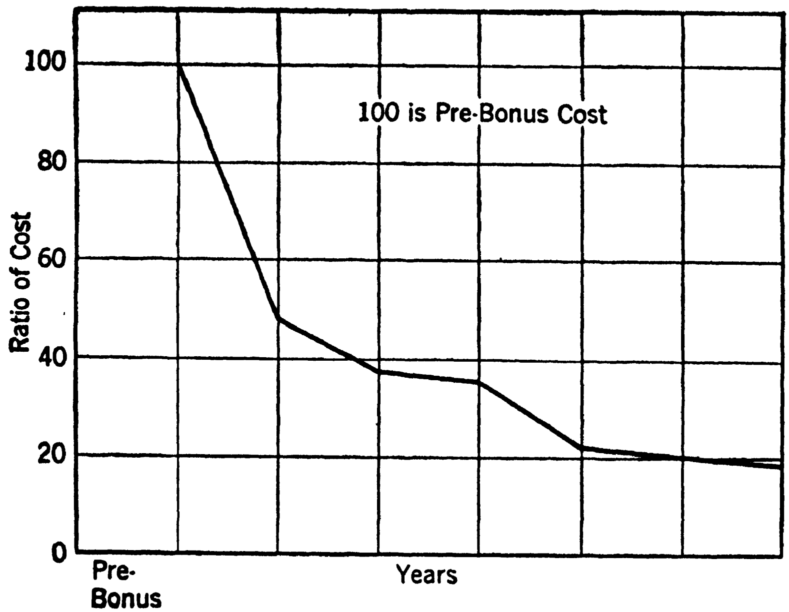


Figure 84. Costs Under Group Bonus Application

force, is paid the percentage increase in his wages or salary during the succeeding four weekly pay days. In the meantime, a committee representing management and trade unions studies current conditions and sets up a standard for the next month. Thus piece rate wages are provided above task, but rates follow rather than precede accomplishments. A minimum day rate is guaranteed and apprentices are allowed double percentage. One company reports an average production increase of 40% during the first two years and claims that the plan definitely stimulates cooperation. In America, it is considered wiser to make the task as permanent as possible and confine all adjustment to the rate. We emphasize the one best way in so doing and reduce that variable to a constant. The Priestman plan reduces the rate to a constant and makes a higher or lower labor cost per piece by adjusting the task. Nevertheless, where labor is completely organized or where piece rates have been abused by

cutting, such a plan may be of value. The mutual study of conditions is in itself perhaps the main advantage.[5]

Group Gantt Plan.—An eastern silk company employing 3,600 employees has for many years used the Gantt Task and Bonus plan both for individuals and for groups. It prefers the individual application as far as possible but has found the group application necessary for many situations. There are 1,300 men and 900 women on the plan one way or the other. Tasks are carefully set, individual production records are kept in all cases and rates are readjusted quarterly. The usual plan has been modified to pay half the bonus at 90% task. This is like the Merrick differential piece rate plan except that the latter plan does not have a day guarantee.

Group (50-50) Sharing Plan.—A mid-west gas engine company introduced seventeen years ago a "gang system" with the object of eliminating the "narrow necks" and fostering a team spirit that would encourage every man to do all in his power to increase the earnings of his gang. Previously, an employee would remain idle if he caught up with his particular job and it was against his principles to do anything he considered outside his special job. The gangs vary in numbers from five to about 125. In some cases, a whole department is classed as one gang; in others, particularly where there are many highly skilled employees performing different operations, there are several gangs in one department. In addition to employing the gang system in all productive departments, it is applied to most of the "nonproductive" departments. These include the toolmakers, stockkeepers, janitors, carpenters doing crating work, laborers handling incoming materials, receiving clerks, and shipping clerks. The company claims:

1. The cost of inspection has been reduced about 70%, that of job standardization about 60%. The cost of production counting is also much less.
2. Quality is better, rejections and complaints have diminished.

Group (75-25) Sharing Plan.—A Pacific seaboard automobile company uses a high task sharing plan in which men of two different hour rates are placed in the same group.[6] Seventy-five per cent of the group saving is paid as a premium, but is distributed equally among the members of the group and not prorated on the time earnings which differ. To protect the quantity of production they set

[5] For further discussion of this kind of cooperation, see *Co-operative Production* by Henry Atkinson.

[6] A. B. Celander, *Management Division Quarterly*, A. S. M. E., Vol. L, Nos. 9-12.

a minimum time or high task at which the sharing begins. To protect the quality of production they set a maximum time of 133⅓% task at which the sharing ends. The earning at this maximum production would be 1.25 of base wages, but, since there are two base rates, the money saved would be on a rate between the two. Wages below task are guaranteed at the two rates. Groups of about seven men are formed, each member usually doing three or four operations.

For instance, a connecting rod goes through twenty-two machine operations. Standard time is .044 hours per man. Hourly rate per class is \$.60, making standard labor cost per man-operation \$.027. If the production per day is 236 rods and the minimum number per day is 180, there would be a saving of 56 rods for premium. Seventy-five per cent of \$.027 above is \$.02 per piece, and \$1.12 for 56 pieces. The \$1.12 is added to each man's day wage regardless of which rate it is.

The plan facilitates finding the labor cost of parts, and the exact amount of individual machine time necessary for a given number of motors per day. This, in turn, governs the number of men required in the production departments and also whether it will be necessary to work overtime on any machines in order to meet requirements.

Task Times Tabulated.—The work of the time study man, or analyst, is aided by a set of tables giving the seconds and minutes consecutive from 1 to 60, converted into decimals of one hour. Another gives the premium rate to minimum pieces from 1 to 200. In order to distinguish the lower premium rate from the higher one, the latter carries a zero prefixed. For instance, the premium rate of .019 = \$.237, giving the higher rate as against premium rate of 19 = \$.189 as applied to the lower.

It is claimed that spoilage is kept to a minimum. A check of 1,143 connecting rods that were finished on a given date by a group of seven employees shows that the first operator lost three by misplacing them in one of the milling fixtures; the third operator misplaced two in the drill jig and one in the straddle milling operation. A total of six spoiled and 1,137 passed. Thus five men out of seven never missed once, and in all but one instance caught the spoiled rod on the next operation. This is about ½ of 1% spoilage, which is considered good.

A Group Point Incentive Plan.—A large company of manufacturing chemists uses a novel plan in their laboratories.[7] "In the

[7] *Factory and Industrial Management*, Vol. LXXVI, No. 5.

packing and shipping room the basis of the premium is three points for each order handled and one point for each unit included in an order. The premium is one cent for each point—about 10,000 points per employee. A unit may be a single bottle of medicinal tablets, or it may be a previously packaged carton of 10 or 100 bottles or packages. The allowance of one point per item works out with surprising fairness, despite the range in item sizes. Likewise, the three points per invoice is surprisingly equitable, though some invoices call for but one item and some are two or three pages long.

Reduces Number of Employees.—"Changes in the size of packages seem at first thought to work against the shipping room employees, if business continues at the same level, though shipments are in larger units, there are fewer units on which to pay premium. What has happened is that paying a premium on a unit basis has helped to force shipping room economies. A year ago there were four order pickers. Today, with more business, there are three. With packaging improvements the premium fell off a bit, and when the second best order picker left, the others found it possible to keep up with the work without hiring a new man. They are assured that in case of a temporary overload an extra man can be put on, but that normally the three are equal to the task. The remaining employees receive more than the unreplaced man's premium. In effect they also split part of his pay.

Example of Calculation.—"Suppose the department handles 10,000 orders in one month, and that these orders include 200,000 unit packages. If, to simplify the figuring, we omit allowances for absences and holidays, the premium, with 20 employees in the department, is figured as follows:

Orders handled	10,000	
Points per order	3	
		30,000
Packages handled	200,000	
Point per order	1	
		200,000
Points earned		230,000
Quota, 20 men		200,000
Premium points earned		30,000
		.01
Premium earned		$300.00
Premium per worker		$15.00

"In case the twentieth employee were eliminated and his premium split among the other 19, each would get but 75 cents per month additional. Instead, the premium of the reduced personnel works out in this manner:

Points earned, as above	230,000
Quota, 19 men	190,000
Premium points earned	40,000
	.01
Premium earned	$400.00
Premium per worker	$21.05

"The addition of $6.05 to each first-of-the-month pay check in the department is a real incentive. At the same time there is a saving to the company, for the total addition to premium checks does not equal the wages and premium of the employee who was eliminated. Altogether, because of this and other savings, the payroll record of this department is now running about $3,000 a year less than a year ago, with volume about 10% heavier.

Stimulates Teamwork.—"In this, as in the granular effervescent salts department, there is noticeable teamwork in maintaining flow of production. In the shipping room this shows itself particularly toward the end of the day. Those who work in the department know that their bonus is computed on a basis of completed shipments. Therefore as the afternoon draws to an end those whose work would count only on tomorrow's 'production' may move temporarily to some other task, so that all possible shipments may be actually completed at quitting time.

"Flow of production and reduction of the regular payroll are, however, only two of the gains which we can fairly ascribe to the group bonus. One very important change has been the elimination of overtime in those departments in which the bonus is paid.

Increases Regularity.—"In the first place, it is understood that short absences for sickness or prearranged half-day absences for such purposes as Christmas shopping can be arranged but any unapproved absences add to the departmental quota and therefore cut down on the premium. As a result, there are seldom overtime payments, whereas before overtime was becoming a serious problem.

"Absences are deducted in figuring the premium quota, in the following manner;

Departmental point quota 19 × 10,000		190,000
Deduction for holiday 19 × 8 hrs. =	152 hrs.	
Other absences	104 hrs.	
Transfers to other departments	37 hrs.	
	293	
Points per hr	50	14,650
		175,350

"In this case it may be assumed that the 104 hours' deduction for absences is chiefly due to the absence of two employees during one-fourth of their month. Under these circumstances the premium earned would be divided by 18.5, not by the normal 19. If the mathematical consequences of reducing the quota for actual reduction in working hours caused by absence, and at the same time reducing the premium divisor, are figured out, it will be seen why the employees are so willing to avoid overtime.

Facilitates Readjustments.—"The result of reduction for departmental transfers is also worth noting, as it is another gain with which the group premium can safely be credited. The foregoing computations show that when a man is temporarily transferred to another department, his time is deducted from his own department's quota, thus increasing the departmental premium. But his absence during the transfer does not deprive him of his own share in the premium. Because part of the results of the quota deduction accrue to his own benefit, he is actually paid a slight premium for permitting himself to be transferred. The result is that all the employees stand ready to fit in wherever they may be needed, with a willingness that could scarcely be expected under any other current compensation method.

"Vacations, too, have automatically ceased to be a problem. Like other absences, they bring about departmental quota reductions. Therefore, if a department can get along without temporary replacements during vacation time, there is a larger premium for all concerned. As a natural result, the employees in each department voluntarily work out and adhere to a mutually agreeable schedule of vacations that keeps summer production running smoothly without resort to substitution."

Group Premium by Weighted Factor.—On certain kinds of so-called nonproductive work, the output is not directly proportional to the effort expended, for example, material handling, receiving, storing, and issuing of raw materials and the like. Investigation of this kind of work at an electric equipment company[8] has shown

[8] A. S. M. E., *Management Division Quarterly*, Man. 50.

that with an increased effort of approximately 10% on the part of the employee it is possible to increase his output about 100%.

As an example of this condition, take the case in which a man goes to a storeroom presenting a requisition for one piece of a certain item. To supply this piece the storeroom attendant receives the requisition, refers to his records to locate the proper bin, goes to the bin, picks up a piece, and delivers it to the man at the window, recording the withdrawal in the ledger.

Had this requisition specified two pieces instead of one, the work involved on the part of the storeroom attendant would have been very slightly increased, yet the output would have been doubled. In order, therefore, to place work of this nature on an incentive basis, it is necessary that this condition be taken into account. The following formula was accordingly designed to be used in such cases:

$$\text{Hours Allowed} = \text{Hours Actual} + F \times (\text{Hours Standard} - \text{Hours Actual})$$

where F is a factor representing the increase in effort necessary to bring about an increase of 100% in the output. In most cases this factor is equal to approximately .10. An example will illustrate the method of figuring earnings from the formula. In a storeroom there is a group of nine men. In a certain pay period there were 96 working hours, or the "Hours Actual" was equivalent to 96 $\times$ 9, or 864 man-hours. Material for 700 control-panel sections was delivered to the floor by the storeroom group at an allowed time of 1.50 man-hours per panel. The "Standard Time" would, therefore, be equivalent to 700 $\times$ 1.50, or 1,050 man-hours. Using a factor F equal to .10 and substituting in the formula, we have,

$$(1{,}050 - 864)\ .10 + 864 = 18.6 + 864 = 882.6 \text{ man-hours allowed}$$

Indirect production of all sorts has been put on group payment. Plans for such work are treated in more detail in Chapter 18.

Group Wennerlund Efficiency Bonus Plan.—An automobile company, noted for its quality standards, has used a group bonus plan[9] throughout its productive departments. The management does not believe that it loses the advantage of individual initiative for the reason that the members of each group who have ideas or knowledge of methods that will increase the output of the group have every incentive to use their ideas themselves as well as to transmit them to their fellows.

The computation for purposes of determining wages and for cost are very much simpler by this method. It is only necessary to keep

9 Metropolitan Life Insurance Co., Pamphlet No. 3.

track of the output of each group rather than the output of each individual. Only finished parts are counted so that it is unnecessary to keep track of foregoing operations.

Quality of production is not sacrificed because the inspection department is entirely independent of the wage payment plan and is particularly charged with the responsibility of maintaining quality, understanding that there is always a tendency to slight the work when the employees are under an incentive plan.

Based on Careful Job Standardization.—The standards for each operation are established through standard times which are set as the result of time study. It is possible to get operation costs but the primary interest is the cost of a completed product.

Operations deviating from the standard are reported by means of time tickets. These alone are necessary for obtaining the cost. All other operations are standard in cost. The method involves the setting of standard times on each part entering into the product, summarizing these standards according to the operations performed by each group. The time value of the completed product as reported by the inspection department, which is independent of the incentive plan, is computed daily and summarized by each bi-monthly pay period so that by comparing the standard time value of the work turned out each day and each pay period with the elapsed time required by the employees in the group to turn out this work, a ratio between the work turned out and the time required to turn it out, is obtained.

Employee Paid for All Time Saved.—The company agrees to pay 1% bonus on top of regular wages for each per cent that the above described ratio exceeds a predetermined point for an entire pay period. The standard of ratio or efficiency varies from 70% to 80%, depending upon the kind of work done in each group. As the average efficiency of the plant is approximately 90%, the incentive earned varies from 10% to 20%. After standard efficiency is reached, the cost is practically constant so that it is known if a standard of efficiency in excess of the starting point is maintained the costs are at or below standard.

Information on other group applications is given in the chapters on the various plans.

CHAPTER 17

INCENTIVE PLANS SUPPLEMENTARY TO PRODUCTION

A company that enjoys good management, usually employs incentives of one type or another.—E. E. BRINKMAN.

Age May Be Ignored in Factory Training.—Learning ability has recently been studied at Columbia University by Dr. E. L. Thorndike.[1] He finds that age has little to do with it. "All conclusions point to the fact that the general laws of learning are substantially the same from the age of 15 to 50." We can, therefore, apply to all adult learners the same rules of training and expect response according to a single general law. Such a law is given below. It should be remembered, however, that the rate is relative only. The time taken will always vary with the jobs and with the individuals.

Rate of Progress in Learning.[2]—"Analysis of many thousands of cases has enabled us to formulate a curve (Figure 85) showing the average reaction of the new employees to a task with which they are not familiar. It is very often assumed in working out plans for remunerating new employees that a steady increase in efficiency should be expected from them. We believe that we have discovered an absolute fact that in the average worker, when he or she has exhausted about one-half the normal training period, there must be expected a period of time, depending upon the nature of the work, where progress in skill practically ceases. Then after a short while they attain the balance of average proficiency very rapidly. Especially in plants employing female labor, the loss of operatives before they have become fairly efficient workers is a very serious problem and we believe very largely due to the fact that their remuneration is based upon a required constant increase in proficiency which is practically impossible for the average worker to maintain."

A Combination Plan for Beginners.—Since a piece rate is discouraging to a beginner and a day guarantee is lacking in incentive,

[1] *Adult Learning*, by E. L. Thorndike, and *Survey Graphic*, Vol. XV, No. 4. See also Prof. Barnes' studies, Bulletins of the University of Iowa, 1928-1941.

[2] This paragraph is paraphrased from C. M. Bigelow, *The Management Review*, Vol. XVII, No. 9.

it is desirable to use an earning curve such as that of the Barth plan up to task. We have seen that this plan is not very effective for above task work, so that it is necessary to combine with it one of the plans which is effective above task. Although there are

APPRENTICE RECORD

Name *Mary Jones* No. *161* Operation *Feed* Class *II* Training Period *6* Date Started *1/3*
Address ______ Age ______
Experience ______
Education ______
Married ______ People dependent upon support ______
Born ______
Father Born ______
Where last employed ______
Position held ______ Wages ______
Where before that ______
Position held ______ Wages ______
Reason for leaving last job ______
Reason for leaving next to last job ______
Employed before by this Company? ______
Under whom ______
Relatives employed here ______

Hours Worked	Wk.	% Efficiency Theo.	% Efficiency Actual	Pay Theo.	Pay Actual	Paid
48	1	15	18	11.50	11.50	✓
48	2	27	31	11.85	11.85	✓
48	3	34	38	12.20	12.22	✓
48	4	39	40	12.55	12.55	✓
48	5	42	44	12.90	12.90	✓
48	6	45	40	13.25	12.90	✓
48	7	47	50	13.60	13.60	✓
48	8	48	48	13.95	13.95	✓
48	9	49	54	14.30	14.30	✓
48	10	52	57	14.65	14.65	✓
48	11	58	62	15.00	15.00	✓
48	12	70	74	15.36	15.36	✓

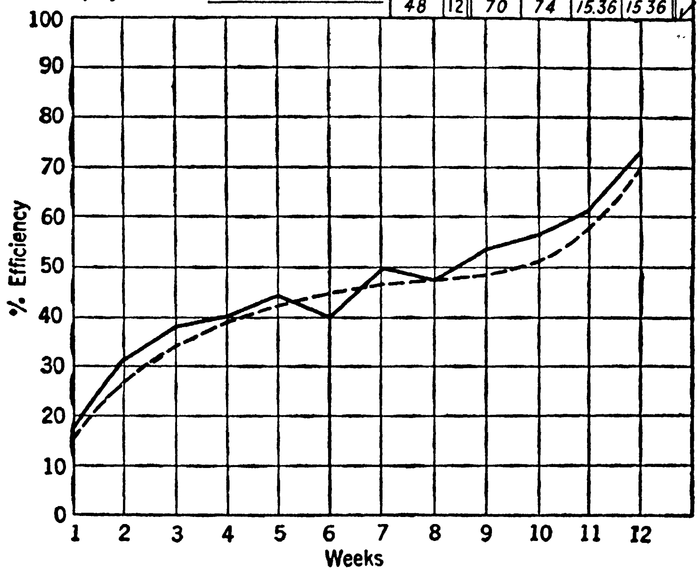


Figure 85. Plateau in Rates of Learning

other plans which might be so combined (see Figure 30), we have preferred the Gantt plan. We have also applied the Barth formula to high task contrary to intended usage by itself. The alteration makes little difference in earning below task. The high piece rate (Figure 86), could be extended back to the (70, 84) point and the

step bonus avoided, but the postponement is a better means of assuring at least task production after the learning period. This portion of the curve between 70% of task and task provides a premium relative to any lower base, say $B = 80\%$, which should narrow the learner's plateau. Incidentally, this Barth-Gantt combined plan is one of the best plans for any employee, new or experienced. The accelerating premium plans, Chapter 15, are the only other plans which have so many good features and so few undesirable ones.

Decreasing Auxiliaries for Beginners.—Any rigid earning curve is sure to discourage some beginners because the time of learning is an individual matter. For this reason it is common practice to devise some easily changed arrangement in which wages are based on the length of employment and the rate of improvement. For instance, a beginner may after a day or so be put on piece rate plus auxiliary sums. The latter may be made to decrease from nearly a full day wage to zero, according to a table. A company manufacturing trousers allows 5/6 of the day wage for the first week, 4/6 for the second week, 3/6 for the third week, and so on. At the end of five weeks, the auxiliary day wages have decreased to zero and the novice is wholly on piece work. This particular scale does not, however, follow the law of learning.

We have found it advantageous to express these auxiliaries in percentages because percentages make even the auxiliaries vary with the effort.[8] If a certain job can ordinarily be learned in six weeks and the beginner can do a third of the task the first week, the wages for that week may be piece rate plus an auxiliary of 200% piece rate, that is, a total of 300% piece rate. For the second week the auxiliary percentage may be reduced to 150%, that is, a total of 250% piece rate, etc. Since all learning processes follow roughly the principle of harmonic intervals, it is helpful to divide a semi-circumference into the number of weeks for the whole learning period and to use the diametrical projection lengths to proportion the auxiliary percentages. The number of weeks and the size of the percentages may be announced in advance, or they may depend on individual progress with the percentage announced at the beginning of each successive week. In either case the beginner should be allowed to receive the full amount resulting from the arrangement even if his wage exceeds the sum anticipated by the employer. Thus exceptional effort will be rewarded, not on the basis of flat production but on the basis of progress in learning.

[8] Society of Industrial Engineers' Convention Report, Detroit, 1922.

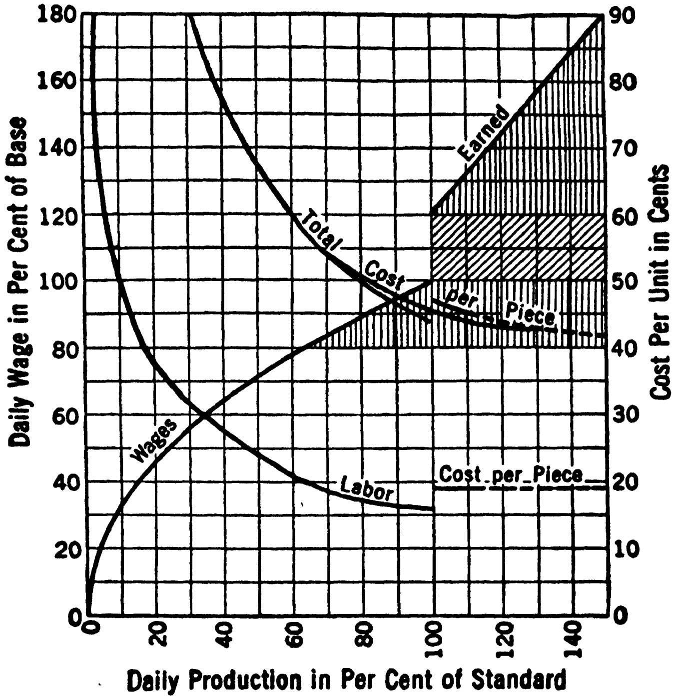


Figure 86. Barth-Gantt Combination Plan

TABLE 60. BARTH-GANTT COMBINATION DATA

	Per Cent of Production H_s/H_a	Per Cent of Total to Base Wage for Full Day $E/H_a R_h$	Total Daily Wage in Dollars E	Number Pieces per Day	Time Saved per 8-Hr. Task in Hours $H_s - H_a$	Labor Cost per Piece in Dollars	Total Cost per Piece in Dollars
BARTH	0	fictitious	0	0	fictitious	0†	3.84†
	10	32	1.21	2.4	− 72.0	.50	2.22
	20	45	1.72	4.8	− 32.0	.36	1.28
	30	55	2.10	7.2	− 18.6	.29	.94
	40	63	2.43	9.6	− 12.0	.25	.77
	50	71	2.71	12.0	− 8.0	.23	.67
	60	78	2.97	14.4	− 5.3	.21	.60
	66	81	3.10	16.0	− 4.0	.19	.55
	73	85	3.27	17.5	− 3.0	.19	.53
	80	88	3.41	19.2	− 2.0	.18	.51
	89	94	3.62	21.4	− 1.0	.17	.48
	*100	100	3.84	24.0	0.0	.16	.46
GANTT	100	120	4.61	24.0	0.0	.19	.46
	114	137	5.26	27.4	1.0	.19	.44
	133	160	6.14	32.0	2.0	.19	.43
	145	174	6.68	34.8	2.5	.19	.42

* This row given for comparison only. † Not per piece.

Vice-versa, subnormal progress, including standing still, will be automatically penalized. It makes all of the wage dependent on performance and yet permits a reasonable weekly wage from the start. This plan, periodically adjusted to individual progress, is the most flexible plan for beginners yet devised. It is not complex and may be counted upon to shorten the learning period without undue severity. It was first used by the author in 1920.

Incentives for Apprentices.—Long practice has demonstrated that a company using skilled men can afford to maintain twelve to fifteen apprentices to every 100 journeymen. With skill as scarce as it has been recently more companies should take this responsibility and in many cases should go beyond 15% since only about 60% of the boys who start such courses normally remain to complete them. In the United States apprentices have usually been paid wages but at low rates (see Chapter 1) plus a $100 bonus upon satisfactory completion of a full program. Except during war periods this program has usually extended over four years or about 8,400 hours. The whole time is generally divided into eight periods and a change in wage rate made at the end of each period. These rates may be predetermined in per cent of the prevailing rate for common labor, in which case they exceed 100% after the first year, or they may be worked backwards from the prevailing journeyman's rate as the 100% to be expected at the end of the program, in which case they start anywhere from 35% to 64% of the journeyman's rate.

The average rate in United States machine shop industries as of August, 1940, was $.481 per hour against an average of $.864 per hour for skilled workers.[4] A few companies prefer to assign the increased rates according to merit, that is, without any announced schedule but experience favors an advance schedule. If the latter is used, some incentive may be obtained by allowing two or even three separate schedules. This has been called the XYZ plan. The X schedule is that of minimum rates. The Y schedule provides two or three cents more than the X schedule for the second period and the Z schedule provides four to six cents more than the X schedule for the second period, etc. Which schedule the apprentice will follow depends on his demonstrated merit and that is usually judged by the supervisor of apprentices, but it may be determined by the more formal merit rating if such is in existence at the plant. Naturally these shifts in schedule may be worked both ways so that a negative incentive is in force as well as the positive one. On the

[4] *Personnel,* Vol. 17, No. 2, pp. 108-116, and Bureau of Labor Statistics, Release No. 9780.

whole the practices of large American companies are at considerable variance and undoubtedly some of them need deliberate remodeling along the lines of the more successful ones.

Other incentives used are: (a) job preference after graduation, (b) opportunities for specialized training, and (c) advancement as result of examination, all of which are more nonfinancial than financial in their appeal. Still others of a financial nature may be used, such as: (a) provision of tools and textbooks, (b) special bonuses throughout the program, and (c) remittance of tuition and fees for successfully completed evening courses supplemental to the trade involved. Some companies allow piece work at certain stages of the program, but this is questionable at any time and definitely unwise under shorter, intensified programs. The real production in any training is proficiency, not volume of material goods.

Promotion Scales for Apprentices.—A large electric company[5] has worked out a careful program of promotion, based on performance ratings and leading by two charted paths to two different rate classes of trade work. These two paths have the same rate advances, ordinates, on the chart excepting the final ones. The difference in paths is ingeniously arranged by time credits which shorten the abscissa intervals for the better group of apprentices. The two scales are compared below with a partial preferred number series. The factor for the latter is $\sqrt[20]{10}$, or 1.122. (See Appendix A.)

WAGE RATE IN CENTS

Original Scale per Hour for Each 1218 Hours		20 Series .1 to 1.0, Omitting First Six and Last Four Items
Path I	Path II	
20	20	20
22	22	22
24	24	—
—	—	25
26	26	—
—	—	28
29	29	—
32	32	32
35	36	36
—	—	40
41	41	—
—	—	45
—	—	50
54	—	—
—	—	56
—	62	—
—	—	64

5 *Mechanical Engineering*, Vol. 48.

The slight changes necessary to conform to the preferred number series would have resulted in smoother curves and more natural advances.

Incentives for Quality of Product.—The recognition of superior workmanship on a given operation by means of higher than ordinary hourly rates is very ancient. Today, this practice is less justified on account of the extreme subdivision of work and the better control of tools, materials, etc. The present need, as a consequence of the quantity incentives, is rather for an extra check on quality. The quality incentive is, therefore, a secondary measure and is usually applied in addition to a quantity incentive. It is often as bad for an employee to overdo a quality standard as to underdo it. Defects may, accordingly, have two fields or a plus and minus set of limits. The nature and degree of these must be standardized for measure and for instruction. No incentive should be expected to maintain quality without the full program of design, purchase by specification, initial investment in equipment, maintenance of tools, use of gauges, and suitable inspection.[6] Neither should it be forgotten that promotion is still the strongest incentive for superior employees.

One of the simplest types of quality incentive is that used in the ceramic industries.[7] Each individually made article is marked with the number of the employee and the date of work. If a piece proves defective, that is recorded and a periodic account is made on the total defects coming from each employee. A record of no defects entitles the employee to a 10% premium. For one defect he receives only 8%, for two defects 6%, and so on down to five defects for which he forfeits all premium. The danger in these premiums is that the forfeits may be so bungled as to seem personally punitive. If this is avoided, if the check acts promptly enough to avoid further labor on the defective part, and if the response effort does not encroach unduly on the time factor, the quality premium will aid cooperation. If all of these conditions are not fulfilled, quality may be better protected by putting the expense into more rigid tooling and inspection. It may occasionally be practical to use a system based on the number of customer complaints.[8]

Example of Quality Premium in Textiles.—A simple quality premium has been in operation for fourteen years at a mid-west silk

[6] "The Control of Quality in a Manufactured Product," by J. H. Marks, Packard Motor Car Co., *A. S. M. E., Quart.*, Man. 50-13.

[7] A similar application to the paint industry may be found in W. O. Lichtner's *Time Study and Job Analysis*.

[8] A. M. A. Production Executive Series No. 67.

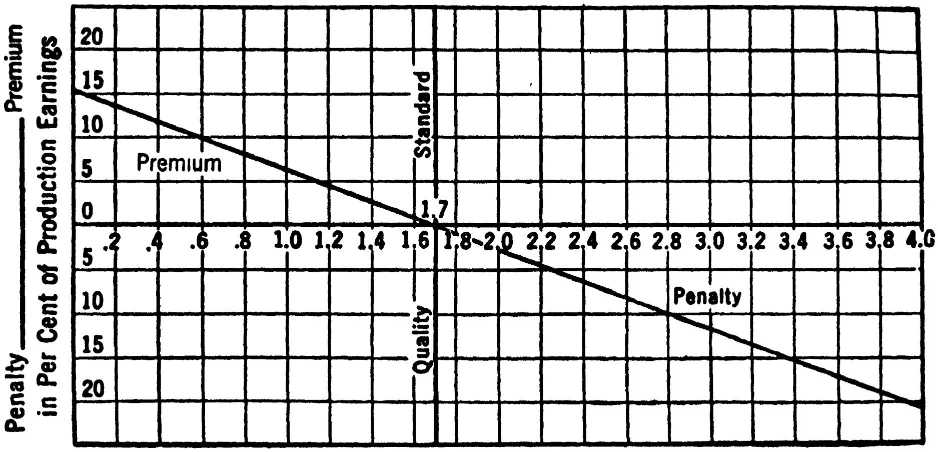


Figure 87. Quality Premium Chart

TABLE 61. QUALITY PREMIUM SCHEDULE FOR KNITTING HOSIERY

% Wrong Classification	Premium of Production Earnings	% Wrong Classification	Penalty of Production Earnings
0	15.3%	1.8	.9%
.1	14.4	1.9	1.8
.2	13.5	2.0	2.7
.3	12.6	2.1	3.6
.4	11.7	2.2	4.5
.5	10.8	2.3	5.4
.6	9.9	2.4	6.3
.7	9.0	2.5	7.2
.8	8.1	2.6	8.1
.9	7.2	2.7	9.0
1.0	6.3	2.8	9.9
1.1	5.4	2.9	10.8
1.2	4.5	3.0	11.7
1.3	3.6	3.1	12.6
1.4	2.7	3.2	13.5
1.5	1.8	3.3	14.4
1.6	.9	3.4	15.3
1.7 (Standard)	.0	3.5	16.2
		3.6	17.1
		3.7	18.0
		3.8	18.9
		3.9	19.8
		4.0	20.7

hosiery plant. The plan applies to 250 women, or one-twelfth of the employees. An inspector receives neither a premium nor a penalty when her wrong classification is equal to 1.7%. This figure was found by a very careful analysis and represents a standard which allows for human deficiencies for this particular work. When the percentage of wrong classification decreases below 1.7%, the inspector receives a premium which increases according to a graduated scale, as shown on the schedule in Table 61. On the other hand, when the wrong classification exceeds 1.7%, a penalty is imposed, as shown on this schedule. The per cent of wrong classification is obtained by a check of reinspectors who are paid a flat salary. Occasionally, a super-reinspection is made on the part of the superintendent or his assistants, to verify the findings of the reinspectors. These precautions are taken to insure that all products are properly shipped according to style, size, and color.

The schedule also indicates the weights of the different kinds of imperfection on the point basis, which, in turn, determines the per cent on classification. The inspectors are paid according to production, and the per cent premium or penalty is applied to the production earnings. Figure 87 shows a graph of this quality premium schedule.

Rules for Calculating the Premium.—For each .1% increase over 4.0% imperfections, increase the hourly penalty .9%, Multiply the percentage by the piece rate earnings in order to determine premium or penalty in money. Imperfections are determined weekly by points; 25 points are equivalent to one imperfection. Table 62 gives the imperfections with their standard point equivalents.

TABLE 62. POINTS FOR IMPERFECTIONS IN KNITTING HOSIERY

Imperfections	Standard Points	Imperfections	Standard Points
Hole	50	Pull Threads	20
Seconds	50	Mismate	10
Mend	40	Reboard	10
Irregular	30	Redye	10
Firsts	30		

An important feature of the plan is the posting of the results. The girls' names are listed in the order of their accomplishments. The number of imperfections is placed after the names and a red line drawn at the location of no premium. No additional clerks are required. This system has given very good results and the prin-

ciple has proven to be correct and fair. The company is extending it to office operations and to such factory departments in which the element of quality is a determining factor.

Another hosiery company similarly establishes a standard of imperfection, 2½% of production, and pays a premium of 12% standard hour wages for each 1% reduction of imperfections. This makes a maximum quality premium of 30%. It also reverses as a penalty.[9]

Example of Quality Bonus in the Film Industry.—For eighteen years, a large company has applied to film spooling an arrangement for rate adjustment which is based on quality. The plan applies to 250 women employees. There are three classes of base rates; namely, A, B, and C. Class A is the full base rate, with a drop of four cents, usually, between A and B and between B and C.

A class A operator is a fully qualified operator and only 5% of her work is inspected. A class A operator, having one defect reported, will receive a caution and will be shown the defective work. For one week subsequent to the discovery of this defect, the operator's work will receive 100% inspection. After one week, if no further mistakes have been found, the operator's work will receive only 5% inspection, as formerly. If within thirty days, from the date of the finding of the first mistake, a second mistake is reported for this operator, she will be reduced to class B rate and her work will receive 100% inspection for a period of two weeks. If, during the two weeks' period, no further mistakes are found, she will be advanced again to class A rate and her work will receive only 5% inspection. This is superior to "Measured Day" work in that it is impersonal and automatic.

If, however, a second mistake is reported against the operator while on class B, she will be reduced to class C rate, which also carries 100% inspection, for one week. If no additional mistakes are found within that week, the operator will be promoted to class B rate with 100% inspection for two weeks, after which she will be advanced again to class A, if no mistakes have been found. If an operator working on class C is credited with an additional mistake, she will be referred to the superintendent of the department for such disposition as he sees fit.

A second type of bonus is one in which an operator is given a varying number of machines, which he operates as a battery. He gets more pay in accordance with the number of machines run. If the work from these machines is found to be defective, the number

9 A. M. A. Production Executive Series No. 22.

of machines he is allowed to control is arbitrarily reduced, and with the reduction, there is a reduction in rate. The maximum and minimum number of machines which an operator is allowed to run is fixed. The maximum is the number found possible for a good operator to run and still make first-class product. This type of bonus applies to machines operating continuously, where the duty of the operator. is to closely supervise the quality of product and make such changes in machine conditions as are necessary to keep the quality to the highest standards.

Quality as a Part of Rating.—Since the measures of quality vary with the nature of the product, it is impossible here to set up any general scale against which points could be weighted. In specific cases it is, however, often possible to do this. The maximum credits are usually one-fifth of the total but might be more where quality is the major problem. A minimum might also be necessary, that is, for a quality below which all regular production bonus is deducted. Between these limits the scale is made in convenient degrees, usually at equal intervals. Final determination of a man's standing may be made by the department head who in some cases must assign arbitrary values for the degrees. At the end of each six months' period the earned rating enters into the calculation of the worker's individual differential above the base rate for his job.

Incentives for Reducing Material Waste.—Waste elimination incentives, as they are usually called, are those "employed with a view to reducing to a minimum usable material wastes resulting from manufacturing processes." [10] They are only used where the cost of material constitutes a large proportion of the total cost or where the likelihood of much waste amounts to the same thing, notably leather, textile, paint, wood, and food industries. After the most economical processing procedure is established, experience in the matter may be recorded and standards of maximum waste formulated. In few cases is it practical to strive for zero waste but there is an optimum per cent of waste for every case. Time and motion study are as essential here as for any other phase of task standardization. Standard written instructions are made up and employees taught how to carry them out.

The incentive plan itself is simple. It provides a premium related inversely, or nearly so, with the amount of waste per unit of product or per man-hour. When the effort involved is directly proportional to the saving accomplished, the curve plotted between per cent of waste and premium is a straight line. When the effort must increase

[10] F. T. Mack, A. M. A. Production Executive Series No. 65.

more rapidly than the saving, the curve may be a parabola or something approaching that. The premium thus earned is usually independent of any quantity incentive and may or may not be accompanied by that. A waste premium may be applied either to individuals or to groups. If properly managed, this practice should be in no way negative or penalizing. The plan is simple and automatic. It does not fail to work after the novelty wears off as sensational prize campaigns so often do.

Waste Bonus for Lumber Industry.[11]—"The range of production per man-hour for the standard crew was determined to be from 11 to 30 feet, B.M., standard at 26 feet. The waste range was from 36% down to 15%, standard at 20%. The relations between board-

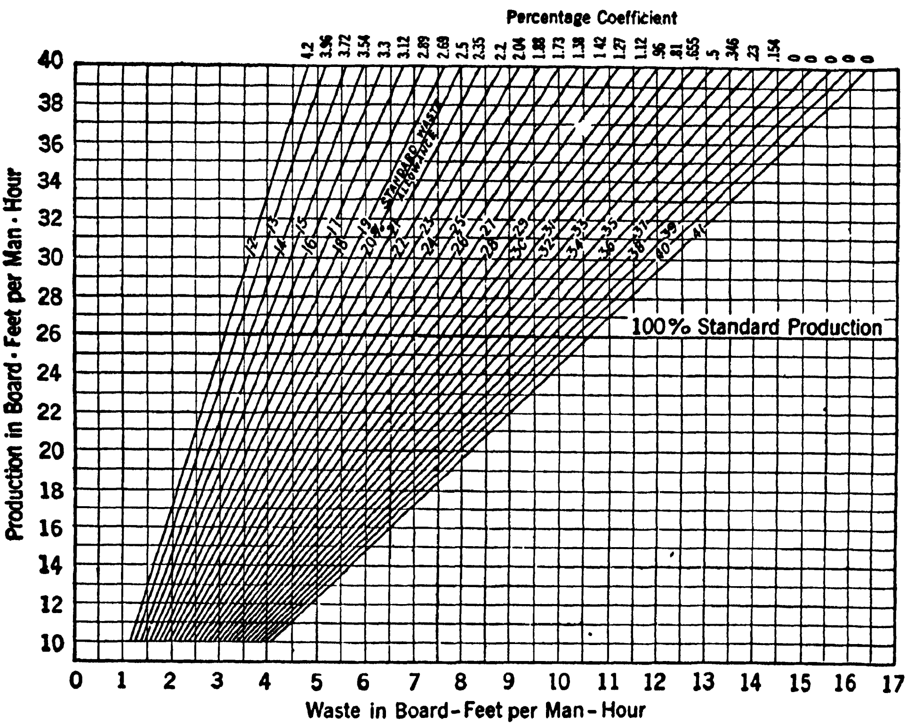


Figure 88. Production Waste Ratio Chart for the Wood Industry

feet-per-hour production and waste, for a range of waste percentages somewhat wider than the standard were first charted as shown in Figure 88. The percentage coefficients at the top of the chart were then determined as follows:

"A graph of bonus percentages and waste eliminations is plotted giving a single straight line curve. The percentages of bonus used

[11] This plan is digested from the writings of Carle M. Bigelow, *A. S. M. E. Journal*, January, 1923, and Kardex Institute, *Management Bulletin*, January 7, 1927.

are determined by experience, and are set to produce the necessary incentive. The standard board footage per hour is 26. The waste bonus shown in Figure 88 applies specifically to this production, therefore the percentage bonus allowed for any percentage of waste divided by 26 gives a coefficient which, if multiplied by any board foot production, gives an excellent differential bonus percentage for both production and waste. For example:

30% waste is allowed 25% bonus,
whence 25 /26 = .96 = coefficient for 30% waste
and the bonus for a production of
30 ft. B. M. hr. = 30 × .96 = 28.8 (29)%
for a production of 25 ft. B. M. hr. = 25 × .96 = 24%, etc.

TABLE 63. BONUS PERCENTAGES FOR STANDARD RANGE OF WASTE AND PRODUCTION IN WOODWORKING PLANT

Waste Percentage	Production in Board-Feet per Man-Hour																				
	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
36	0	2	2	2	2	2	2	3	3	3	3	3	3	4	4	4	4	4	4	4	5
35	0	3	3	3	3	3	4	4	4	4	5	5	5	5	6	6	6	6	6	7	7
34	0	4	4	5	5	5	6	6	6	7	7	7	8	8	8	9	9	9	10	10	10
33	0	6	6	7	7	8	8	9	9	10	10	11	11	12	12	13	13	14	14	15	15
32	0	7	8	9	9	10	10	11	12	12	13	14	14	15	16	16	17	18	18	19	20
31	0	9	10	11	11	12	13	14	15	15	16	17	18	19	19	20	21	22	23	24	24
30	0	11	12	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
29	0	12	13	15	16	17	18	19	20	21	22	24	25	26	27	28	29	30	31	32	34
28	0	14	15	17	18	19	20	22	23	24	25	27	28	29	31	32	33	34	36	37	38
27	0	16	17	18	20	21	23	24	26	27	28	30	31	33	34	35	37	38	40	41	43
26	0	17	19	21	22	24	25	27	28	30	32	33	35	36	38	40	41	43	44	46	47
25	0	19	21	22	24	26	28	29	31	33	35	36	38	40	42	43	45	47	48	50	52
24	0	21	23	24	26	28	30	32	34	36	38	40	41	43	45	47	49	51	53	55	56
23	0	22	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53	55	57	59	61
22	0	24	26	29	31	33	35	37	40	42	44	46	48	51	53	55	57	59	62	64	66
21	0	26	28	31	33	35	38	40	42	45	47	49	52	54	56	59	61	63	66	68	71
20	0	28	30	33	35	38	40	43	45	48	50	53	55	58	60	63	65	68	70	73	75
19	0	30	32	35	38	40	43	46	48	51	54	57	59	62	65	67	70	73	75	78	81
18	0	31	35	38	40	43	46	49	52	55	58	61	64	67	69	72	75	78	81	84	86
17	0	34	38	41	44	47	50	53	56	59	62	65	69	71	75	78	81	84	87	91	94
16	0	36	40	43	46	50	53	56	59	63	66	69	73	76	79	83	86	89	93	96	99
15	0	39	43	46	50	53	57	60	64	67	71	74	78	82	85	89	92	96	99	106	109

Standard Waste

Production Standard

Table 63 is then calculated from the coefficients and gives the direct bonus percentage for each combination of waste and production within the standard range.

"With the proper assortment of carefully dried lumber available and the cutting orders planned for widest possible range of sizes under the order requirements, the plan is explained to the personnel of the cutting department. During the investigation, records of intake, clearance and waste should have been installed. For several weeks a trained woodworking engineer should work continuously in the department, instructing and encouraging the workers. For each pay period the net clearance of product from the department divided by the total number of hours worked by the standard crew gives the board-foot-per-hour production. Net intake less net clearance divided by net intake gives the waste percentage.

"Table 63 shows the bonus percentage of standard wages, which, added to the standard wages, gives the total pay. Suppose, and these are average conditions, that a plant is operating with a clearance of 12 feet, B.M. per man-hour, cutting wages of 50 cents an hour, and 45% waste. The application of the bonus rate resulted in the following saving for each 1,000,000 feet B.M. of lumber used when the standard waste and standard production were attained:

LABOR:

Original Cost
- Hourly wages = \$.50
- Hourly production = 12 ft. B. M.
- \$.50/12 = \$.042 per ft. B. M.

Resulting Cost
- Hourly wages = \$.50 + 65% bonus = \$.83
- Hourly production = 26 ft. B. M.
- \$.83/26 = \$.032 per ft. B. M.

Saving per ft. B. M.
- \$.042 − \$.032 = \$.01

Saving per million ft. B. M.
- 1,000,000 × \$.01 = \$10,000

MATERIAL:

Original waste = 45%
Resulting waste = 20%
Lumber saving = 25%
Lumber cost 1,000,000 ft. (\$70 per M.) = \$70,000
25% of \$70,000 = \$17,500

Total Saving per million ft. B. M.:
\$10,000 (labor) + \$17,500 (material) = \$27,500

"Possibilities as calculated for the cutting departments of the woodworking industry alone show a possible saving of \$107,000,000

annually and in a plant using 500,000 feet of lumber a year, the saving will represent an appreciable reduction in manufacturing cost."[12]

Waste Bonus for Hide Skinning and Leather Cutting.—An eastern meat packing company uses the same principle applied to the spoiling of hides by the carelessness of skinners. A schedule is made between the percentage of cuts to the number of hides skinned and an inverse bonus. The men work in groups and receive a quantity premium as well as the waste bonus. When applied to the cutting of shoes three per cent more material has been saved.[13]

TABLE 64. BONUS TABLE FOR FIREROOM BASED ON CARBON DIOXIDE IN FLUE GAS

Average % of CO_2	Corresponding Area of Chart in Square Inches	Per cent of Weekly Wage as Bonus
7	6.40	6.82
8	6.83	7.24
9	7.25	7.69
10	7.70	8.23
11	8.24	8.69
12	8.70	9.22
13	9.23	9.74
14 and up	9.75	up

Waste Bonus for Boiler Firing.—Bonuses based on the percentage of CO_2 have been used in power plant operation.[14] The percentages were obtained by a Hay's Automatic CO_2 and Draft Recorder. Table 64 shows the established schedule of CO_2 and bonus.

TABLE 65. SAVINGS THROUGH CARBON DIOXIDE BONUS

	Small Boiler	Large Boiler	Large Boiler	Head Fireman	Total
CO_2	10	12	12	—	—
Savings	1.06	1.14	1.14	—	3.34
Bonus	.26	.28	.28	1.00	1.82
Savings to Company					1.52

12 For results of the Bigelow combined production and waste incentive applied to groups of men making kitchen cabinets, see article in *Manufacturing Industries*, Vol. XI, No. 5.

13 *Management and Administration*, Vol. VI, No. 2.

14 *Industrial Management*, Vol. LIX, No. 5, and *Factory*, Vol. LXXVIII, No. 7.

At least 10% CO_2 but no more than 14% is desired. At that point, CO appears which indicates incomplete combustion. The arrangement for a plant operating three boilers is shown for a single 8-hour shift, Table 65. It is also necessary to have a penalty on the percentage of combustible above 30% in the ash. This is established empirically and shown by a curve.[15]

Accelerating Premium for Waste in Textiles.—F. T. Mack[16] presents an example (Figure 89) of waste incentive applied to rug weaving which is of particular interest because the relation of effort to results varies as a parabolic curve, rather than as a direct proportion.

"Each line in an Axminster rug is 'set' on a loom spool. With no waste whatsoever it should be possible to weave a maximum of 125 rugs from one set. Because of inherent loom operations this maxi-

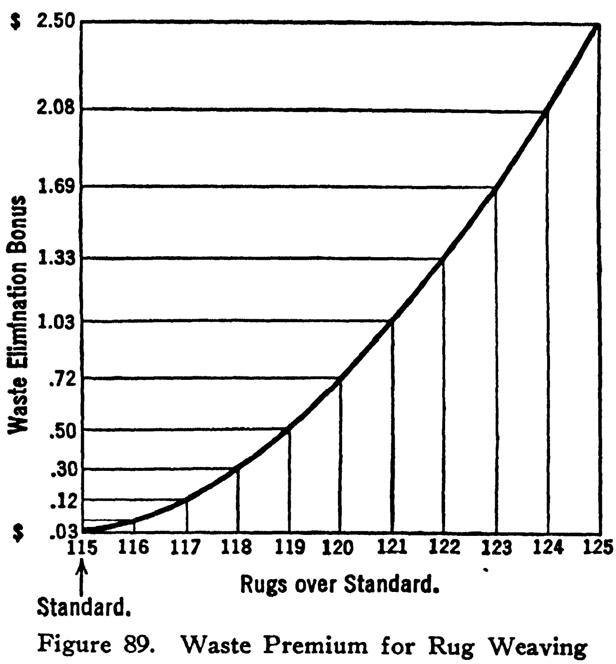


Figure 89. Waste Premium for Rug Weaving

mum is difficult to secure. However, tne standard of 115 rugs as a minimum must be woven by an operator. The operator can, through careful loom operation in keeping waste to a minimum, increase the number of perfect rugs woven. It is much more difficult to operate, conserving material, so as to produce the 123rd rug than to produce the 116th rug, which is but one in addition to the standard set. A higher incentive is, therefore, justifiably paid the operator for the

15 *Factory and Industrial Management,* Vol. LXXVII, No. 2.
16 A. M. A. Production Executive Series No. 65.

123rd rug than for the 116th rug. A maximum incentive is paid for the 125th perfect rug."

It will be observed in some of these cases that a waste elimination premium may bear upon the number of defective units finished as well as upon the number of units of raw material. In short, waste and quality problems may become identical in some industries, that is, where no seconds are allowed.

Where a Prize Is Effective.—Money given as a prize is the usual reward for employee suggestions which are adopted, although royalties and stock bonuses are sometimes provided.[17] The amount of these prizes may be stipulated in advance by grades, but can only be suited to the individual case after the merits are evaluated. Frequently, $1 is paid to each initially. There is usually a committee of executives selected for impartiality and competency to make evaluation. Ordinary awards range from $1 to $500, and the percentage of suggestions adopted ranges from 7½% to 42%.[18] One toy company whose success depends on new and varied products makes a standing offer of $250 a year for five years for each new toy which can be accepted. If the company ceases to produce it before the five years are up, the patent rights revert to the employee. Another company pays a lump sum of two or three hundred dollars to an employee who suggests a means of improving his operation. This practice facilitates the change from old to new methods and increases the number of such improvements.

Special vacation trips for all who make a certain score in number and value of adopted suggestions is sometimes effective. The trip is in addition to the cash prizes and sets up an enviable distinction. In fact, publicity is a vital part of the system. A good suggestion system fills several important needs under present conditions. It tends to replace monotony with interest, to increase cooperation and to serve as a training school for foremanship. It is, however, essential to show employees the kind of suggestions that can be adopted. A simple form is helpful because some employees are awkward in reporting their ideas. A suggestion box is placed in each department to avoid any possible trouble arising from discouragement which a busy foreman might give the suggester. An extra reward of $5 is sometimes paid the employee after he has had five suggestions accepted. If he continues with five more, $10 is paid and after five more $15, etc. Since the first few suggestions come readily, it is the later ones which take real thought and are most likely to be valuable. A system of numbers and colors is often used to keep names out of

17 A. M. A. Survey Report No. 15.
18 *The Personnel Journal*, Vol. VII.

consideration until after awards are made. As patents usually belong to the company, incentives for patents have been neglected.

Annual Waste Elimination Campaigns with Prizes.—During the spring of 1927, the Westinghouse Electric and Manufacturing Co., under the leadership of the late C. B. Auel, instituted a waste elimination campaign, that is, an annual revival in cost reduction. The idea came from the National Management Week movement. Educational exhibits were used and prizes offered. Such a campaign may be made to reach every employee, even down to the sweeper. The most minor wastes are thereby uncovered. It is claimed by one company that the total of such minor wastes exceeds in their case the total of the larger wastes. Over $50,000 was saved during the first trial of this company and it has become a regular custom.

In 1928, the Newport News Shipbuilding and Drydock Co., employing 5,300 men, conducted a similar campaign. Suggestions received from employees, when carefully evaluated, showed potential savings to the company of $250,000 a year. Out of 1,482 concrete ideas considered, 677 were approved and the employees making them substantially rewarded. The 232 suggestions promptly put into effect represent an annual saving of $80,455.

In 1929, the American Society of Mechanical Engineers, with the cooperation of the American Management Association, resumed its support of the movement and decided to set aside April every year as the time for focusing attention on this promising means of waste elimination. Other large companies took up the project with gratifying success, notably, Carnegie Steel and General Motors.

Prizes for Good Safety Record.—The waste of life and limb in American industry has become so excessive that safety engineers are now using every means to reduce the number of avoidable accidents. The Engineering Council Survey, published in 1928, made it clear that the well-managed plant is the safe plant, that "good housekeeping" and responsible leadership can lower both frequency and severity rates without disturbing plant efficiency. Many progressive plants have already achieved great success in this matter. Nonfinancial incentives and prizes have, however, been the usual means. They are applied to departments or groups so that the sport instinct of competitive pride will operate. Some form of publicity, such as house organs, bulletin boards, and graphic representation, is important as a supplement to any safety program.

Incentive Plan for Good Safety Record.—A shipbuilding and drydock company has to deal with nearly every trade. It is not sur-

prising, therefore, that one of the largest of these has fourteen different incentive plans in operation, one of which is applied to safety. The rewards of this plan are paid to members of the yard committee on safety, consisting of 34 representatives and 150 committee men. The safety reward is paid in addition to production rewards. The production reward for most employees is a Halsey premium and for supervisors a possible 5% of salary bonus. The safety men may or may not be supervisors.

Details of Plan.—The management sets aside $10,000 each year for the safety bonuses. Bogies are set up in five steps according to the amount of lost time, Table 66, column (1). This $10,000 fund is reduced for each accident at the yard according to a money scale, column (2). Whatever sum remains after these reductions is divided, one-third to the representatives and two-thirds to the committeemen, but is not paid until after further reductions are made for individual liability. These further reductions are figured in certain per cents per accident within each man's group, column (3).

TABLE 66. SCHEDULE OF PENALTIES FOR ACCIDENTS

	(1) Lost Time in Days	(2) Reduction of $10,000 Fund in Dollars per Accident	(3) Reduction of Personal Share in Per Cent per Accident
Class 1	Less than 7	$ 10.00	.010
Class 2	7 to 43	25.00	.025
Class 3	43 to 70	75.00	.075
Class 4	Over 70 but not permanent	150.00	.150
Class 5	Permanent	250.00	.250

Claims for Plan.—When asked if men would not do their best for safety without extra incentive, the manager replied, "Well, they intend to do so, but they use their brains more effectively when conscious of the possible reward of a hundred or more dollars." The first effect of this plan was to reduce the number of infection cases due to unreported minor accidents. The company record for the first year as compared with that for the previous year showed:

A reduction in frequency rate from 24 to 16 accidents per 1,000,000 man-hours of work (33⅓%).

A reduction in severity rate from 1.92 to .83 days lost per 1,000 man-hours of work (56%).

All this was achieved without the slightest impediment to other programs. In fact, production increased in both volume and speed, quality was maintained and material saved, relative to the best previous achievements. For instance, the completion of a ship was accomplished in 16⅓ months instead of 21 months. This company has long put quality ahead of production. It now believes "the safest way is the best way."

Incentives for Attendance and Punctuality.—Any good incentive on production tends to improve regularity, particularly if it is a group application. If there is little trouble from absence or tardiness, it is questionable practice to arrange a special incentive for these. There are, however, industries which have a distinct regularity problem. For instance, women employees who merely wish to add to the family income but who do not carry the entire support, are prone to take days or half-days out for the sake of home duties. In fact, high wages contribute somewhat to absenteeism of a certain type of employee. This is disturbing to factory control and a real source of present inefficiency. Without a special incentive it is customary to hold irregularity against an employee by some or all of the following means: layoffs, salary or wage reductions, deferred promotions, deferred wage increases, postponement of vacations, vacation reductions, unfavorable notation on personnel records, loss of extra time, assignment to less desirable types of work, and use of visiting nurses to follow up absentees. These means will doubtless continue to some extent where a special incentive is used, but, if they can be relinquished in part, the feeling of penalty will be relieved. The percentage bonus is the most common device. Such bonuses range from 3% to 10% of the regular wage. The difficulty is to set them up so that they will reach the chronic offender after a short loss of time during the work period. An employee may be credited a flat 5% of his wage payable at the end of a perfect month, or he may be credited 3% the first month, 4% the second, and 5% the third.

A few companies allow certain time off with pay, such as one half day a month, when the absence is least undesirable. This is also done on a group competition basis. The department which has the best record in the month is allowed one day off. Each man-day absence counts one unit against the record, and each tardiness counts .3 of a unit against the record. Where there is much commuting, exemption is made for late trains or specific tie-ups. With flexible and humane administration, the plan has been successful to the extent of reducing absenteeism to 4.5 and to 3.2%. As in other matters, periodic posting of records is a strong non-financial incentive.

Example of Regularity Bonus Plan.—An eastern company making scientific instruments has, for twenty-four years, applied an attendance and punctuality bonus plan to 313 men and to 79 women out of a total payroll of 655 employees. No additional clerks are needed. The plan is briefly stated in an Employees' Handbook.

"If the weekly time card shows that an employee has been on time every morning and afternoon and not absent from the plant at all during working hours he will receive on pay day a bonus equal to 5% of his week's wages. To make allowance for absence or lateness for unavoidable causes, he will still receive his bonus if he is absent or late not more than once during any one month. If he has a perfect attendance record for three successive months, he will be allowed two such absences or latenesses without affecting his right to receive the attendance bonus."[19]

Where a good merit rating plan is in effect it is more simple and perhaps just as effective to include attendance in the man-characteristics, giving it about one-fifth weighting as follows:

Percentage Attendance	Points of Credit
100	20 (out of 100)
99.0–99.9	19
98.0–98.9	18
97.0–97.9	17
96.0–96.9	16
95.0–95.9	15
(etc., down to)	
50.0–55.9	1

Tardiness may be included by deducting from the points of credit at the rate of one point for each tardiness over six. The period for these ratings is usually six months.

The Problem of Punctuality.—Bonuses have been applied directly to tardiness, usually in the form of a small percentage on day wages if a man's whole week is free from any tardiness. Those who are never tardy anyway come to look upon this bonus as part of their regular wages and incorrigible late-comers figure that they lose the bonus but do not sacrifice on base pay. Hence if the financial force is to be used for this purpose it might better be in the form of a scale of penalties such as:

Minutes Late	Penalty
1 to 15	1 hour's wage
15 to 30	2 hour's wage
anything more	4 hour's wage

[19] A. M. A. Office Executive Series No. 22.

That is strong medicine and usually cures or kills, that is, some will absent themselves or even quit. The disturbance of vacant machines to operation balance might justify such penalties but most managers prefer to attack the problem through supervision or through non-financial incentives, that is, by foreman discipline or by name posting. The group influence can be brought into the latter by giving honorable mention to all groups which complete a week with perfect punctuality. If this can be done, individual names need not be put up to shame. Example and public opinion are in the long run the surest correctives for these personal delinquences.

Incentives for Length of Service.—Where promotional opportunities are few, many companies award insignia, present certificates, or make valuable gifts to those employees who have served twenty or twenty-five years. To bring incentive to bear on shorter periods an increasing number of companies are making advance provision for extra, or above normal, vacation time with pay. While the most common arrangement is one extra week after fifteen years' service, one liberal company grants one extra week after five years of service, two after ten years, 5% of annual earnings after fifteen years and 10% of annual earnings after twenty years.[20] As to the eligibility requirements for normal vacation with pay, these have been considerably liberalized by: (a) better profits, (b) union negotiation, and (c) the desire to bring policies into line with those of leading companies. Leading practice at present provides one week after one year of service and two weeks after five years. This may be further graded in days but few companies provide for anything longer than two weeks except for very long service. When under pressure for speed in defense orders, some companies encourage their employees to forego vacations by paying them double during the time they are entitled to be on vacation.

Profit Sharing as Incentive to Length of Service.—A metal stamping company has set up a two-column arrangement to relate profit sharing to length of service as follows:

Years of Service	Points Used to Derive Share
1 to 2	30.0
2 to 4	37.5
4 to 6	45.0
6 to 8	52.5
8 and over	60.0

20 N. I. C. B. Studies in Personnel Policy Nos. 29 and 34.

At the end of each year points earned are totaled, divided into the sharing fund, and the resulting point value multiplied by individual credits to determine the share of the fund for each employee who has been on the payroll a year or more. The fund is figured at the same rate, per $500,000, as dividends paid per share to common stockholders. In case of layoff the employee is paid proportionally to his working time.

Length of Service Reflected in Rate.—Where a good merit rating plan is in use length of service may be brought into the rating by setting up a table as follows:

Years	Mos.	Points	Years	Mos.	Points
0	2	1	4	0	11
0	4	2	5	0	12
0	6	3	6	0	13
0	8	4	7	4	14
0	10	5	8	8	15
1	0	6	10	0	16
1	6	7	12	6	17
2	0	8	15	0	18
2	6	9	17	6	19
3	0	10	20	0	20

Thus the maximum of 20 points gives this man-characteristic one-fifth of the weighting out of a total of 100 points. Ratings are figured every six months and determine the amount of individual differential above the job base-rate.

Wage Incentives Based on Standard Costs.—In a very few instances, nothing but standard cost is used as the basis for incentive. This "cost premium" may blend the effect of quantity, quality, material economy, regularity, etc., but so far as wage earners are concerned, it fails to relate the reward and accomplishment specifically enough to point out the time, place, and manner of accomplishment. For instance, the manager of one company, large enough to have eight plants in as many cities, writes as follows:

"Our bonus system is based on savings of any kind—time or material—under standard cost which we took as our normal cost at the time of installing the plan. These savings, no matter how developed, we share with the men fifty-fifty. Our records are not sufficiently in detail to indicate always where the savings are effected."

The cost basis has some plausibility for work not suitable for accurate standardization but the tendency is to take more and more work out of that category.

Production as a Part of Rating.—Productivity itself may be made to influence the individual differential above the base job-rate, usually reviewed every six months. This is best accomplished by dividing the incentive time allowed by the incentive time taken, and this percentage applied to a scale of credit points as follows:

Productivity in Per Cent	Points of Credit
125.0—beyond	25
120.0—124.9	24
115.0—119.9	23
110.0—114.9	22
105.0—109.9	21
100.0—104.9	20 (Standard)
95.0— 99.9	19
89.0— 94.9	18
84.0— 88.9	17
79.0— 83.9	16
74.0— 78.9	15
68.0— 73.9	14
63.0— 67.9	13

The criticism here is that it is a duplication to apply it to those on regular incentive plans and it cannot be applied impersonally to those on time payment until tasks are set for their jobs. When tasks are set other production incentives become practical and can be much more effective.

CHAPTER 18

INCENTIVE PLANS FOR INDIRECT WORK

> We have found over a period of years that the offering of incentives to our employees, beginning with the operators in our plants and continuing on up to the major executives, has proved itself to be a wonderful harmonizer, has encouraged loyalty and has given our employees tangible evidence of our desire and ability to reward for results achieved.—A. S. ROGERS.

Characteristics Common to Indirect Labor.—A manufacturing executive recently wrote, "Labor rates and performance in departments which were organized on an incentive basis appeared to be under reasonably good control, but the nonincentive departments showed a decided lack of such control. Nonincentive employees, whose output could not be measured easily, were on a day-rate basis. This resulted in employee dissatisfaction and led to requests for transfers or wage increases. The problems of control and of equitable labor rates were frequently before us." After devising and installing incentives for such departments the same writer continued. "We wish to report that in addition to installing incentive plans in our two Stores departments, we have operated successful incentive plans in our Electroplating, Automatics and Tool departments, all of which were on a day-rate basis. We are now working on an incentive plan for the skilled groups in our Maintenance department and hope eventually to have all but our unskilled labor groups on incentives of some kind."

Another large company which has long had 95% of its direct producers on wage incentives has today only 30% of its indirect producers on wage incentives.

Thus even today the so-called nonproductive work or indirect production is commonly neglected so far as extra-financial incentives are concerned. It is realized that any deficiencies on the part of indirect producers will lower the efficiencies of direct producers, if not stop them completely, but establishment of task standards for that kind of work is difficult. Experience indicates that the benefits are frequently worth the extra trouble. In a large electric company 70% of the indirect producers are now under incentive wage plans.

For indirect production tasks, the Bedaux or Manit unit is particularly helpful. In regard to this, Oscar Grothe says:

"In all operations, productive and indirect, we set the hourly rates prevalent in our district for the kind of work that the schedule in the department requires, whereby we obtain what we call our standard cost per 'B.' This is weighted against the ratio of the indirect labor, together with the direct production, and gives us the departmental effectiveness. We use that as a basis of compensation or have that basis of compilation for arriving at what this indirect labor and supervision are going to be paid in accordance with the total results of that particular department."[1]

When a "B" unit is not in general use, it is still possible to use a common denominator by expressing tasks in standard hours. It is characteristic of indirect labor that output is not always directly proportional to expended effort. For instance, a stock clerk who brings two packages at a time instead of one, is giving double output for very little extra effort. For this kind of work, the constant premium plan is much used, because the fraction of sharing may be treated as a weighted factor and adjusted to each situation. The general formula is:

$$\text{Earning} = \begin{matrix}\text{Hours}\\\text{Actual}\end{matrix} \times \begin{matrix}\text{Rate}\\\text{per}\\\text{Hour}\end{matrix} + \text{Factor} \times \begin{pmatrix}\text{Hours} & - \text{Hours}\\ \text{Standard} & \text{Actual}\end{pmatrix} \times \begin{matrix}\text{Rate}\\\text{per}\\\text{Hour}\end{matrix}$$

$$E = H_a \quad R_h \quad + F \quad (H_s - H_a) \quad R_h$$

Key to Symbols

E = Earning in dollars (the vertical variable)
H_s = Hours standard (the horizontal variable)
H_a = Hours actual (a constant)
H_p = Hours standard per piece
R_h = Rate per hour in dollars (a constant)
F = Factor of sharing, weighted to represent the additional effort necessary to bring a 100% increase in results

It will be seen that this formula becomes day wages when the factor is zero and piece rate when the factor is 100%. The hourly rate may be divided out of the formula for group application, so that members may be given different rates. In the case of piece rate this becomes $E/R_h = H_s$ or "Hours Allowed." The omission of the hourly rate also allows us to combine a premium or factor sharing with a two rate or step bonus arrangement without setting up two formulas one for below and one for above task.

1 A. M. A. Production Executive Series No. 21.

$$\text{Hours Allowed} = \underset{\text{Actual}}{\text{Hours}} + \text{Factor} \times \left(\underset{\text{Standard}}{\text{Hours}} - \underset{\text{Actual}}{\text{Hours}}\right)$$

$$\text{Hours Allowed} = H_a + F \quad (H_s - H_a)$$

The "Hours Standard" term may be further broken down to unit time times number of units. $H_s = H_{sp} N_p$

where Hours Standard per single piece $H_{sp} = \frac{R_p}{R_h}$.

Examples of Stores or Stockroom Plan.—A large eastern electric equipment company uses these formulas with group application for many kinds of work, one of which is stores.[2] Nine stock men constitute a group. In a certain pay period there are 80 working hours and the "Hours Actual" is equivalent to 80 × 9, or 720 man-hours. Material for 700 control-panel sections is delivered to the floor by the storeroom group at an allowed time of 1.50 man-hours per panel. The "Hours Standard" will, therefore, be equivalent to 700 × 1.50, or 1,050 man-hours. Using a factor F equal to .10 and substituting in the formula, without the rate, we have:

$$\text{Hours Allowed} = 720 + .10\ (1{,}050 - 720) = 753$$

This figure is divided by 9 and multiplied by each man's higher rate. The application to toolroom work is similar.

A hosiery company uses a special Baum plan, or differential constant sharing plan for four classes of stockroom employees.[3] Primarily, the premium depends upon the volume of work but a deduction is also made for errors. The ranges of volume are made high for this work. For volume handled above task the base rate varies:

From 0 to 33% net gain above task,	rate = $.40
From 33 to 50% net gain above task,	rate = .44
From 50% on up,	rate = .48

As in the Baum direct production plan, the wages saved are shared (50-50) between the employees and the company. The net gain referred to above equals $\frac{(H_s - H_a)\ F_d}{2}$ which is a reduced constant sharing and is divided by H_a to find the per cent which in turn determines the rate.

$$\text{Earning} = \underset{\text{Wages}}{\text{Time}} + \underset{\text{Saved}}{\text{Half Time}} \times \underset{\text{Factor}}{\text{Deduction}} \times \underset{\text{Hour}}{\text{Rate per}}$$

$$E = H_a R_h + \frac{(H_s - H_a)}{2} \quad F_d \quad R_h$$

where, $F_d = 1.00 - \%$ deduction for errors as per empirical scale.

[2] A. S. M. E. *Management Division Quarterly*, Man. 50. Also see *Factory and Industrial Management*, Vol. 95, No. 9.

[3] A. M. A. Production Executive Series No. 23.

EXAMPLE: A stockkeeper accomplishes a 75-hour task in 45 hours with two errors. The scale deduction for two errors is 4%.

$$E = 45 \times \$.40 + \frac{(75 - 45)}{2} .96 \times \$.40 = \$23.76$$

With no errors F_d would have been unity and the net gain term divided by H_a would have equaled $33\frac{1}{3}\%$, so that the second rate of \$.44 would have been earned and the total wage would have been \$26.40.

Incentive for Parcel Wrappers.—Salary plus multiple commission is a satisfactory plan for wrapping unless the nature and size of the parcels are extremely varied. Several zones of volume or per cents of task are established. When the first zone is exceeded, an extra \$.10 per day is paid as bonus. When the second zone is exceeded, the extra bonus becomes \$.25 per day. When the third zone is exceeded, the extra bonus becomes \$.50 per day.[4]

Incentives for Material Handling.—The usual means of keeping this phase of management up to requirements is, first, coordinated planning and scheduling, and second, group bonus. Supervision of material handling is often difficult because of its interdepartmental nature. For this reason, all handling is sometimes centralized under a department control of its own. When this is done, it is less difficult to establish uniform standards and to hold every one responsible for definite performances. At the electric equipment company, recently cited,[5] interdepartmental trucking is done on standardized routes and the drivers are rewarded in groups provided they exceed their task amount of trucking. The task is based on the number of packages handled as shown by a system of delivery stubs and the number of trips. Each of the eighty stations is assigned a number and provided with a time stamp. The task rate is about 11% above the guaranteed day rate. The calculation is as follows:

Hours allowed or $E/R_h = H_a + .12\,(.066\,N - H_a)$

where N = Number of packages handled for pay period
H_a = Hours actually worked by group for pay period
H_s = Hours standard = in this case $.066\,N$
(The .066 is the hours per package.)

[4] See *Factory*, Vol. 79, No. 1; Vol. 95, Nos. 7 and 9; Vol. 97, No. 3. Also *Material Handling and Distribution*, December, 1930.

[5] *Manufacturing Industries*, Vol. XIV, Nos. 4 and 5; also *Material Handling and Distribution*, August, 1932.

When the hours actual are down to or less than the hours standard, a higher rate is earned. In the particular case $N = 400$. Since the required effort fluctuates somewhat, an additional factor allowing for such variation is used, .12 in this instance. Locomotive men are similarly treated. If they are handling loaded cars only, the formula simply provides for the hours standard for such complete movement. If they are handling boxes and crates only, the formula becomes:

$$\text{Hours allowed} = H_a + F\,(.3\,N - H_a)$$

where F = Factor allowance or .10 in this instance (The .3 is the hours per box.)

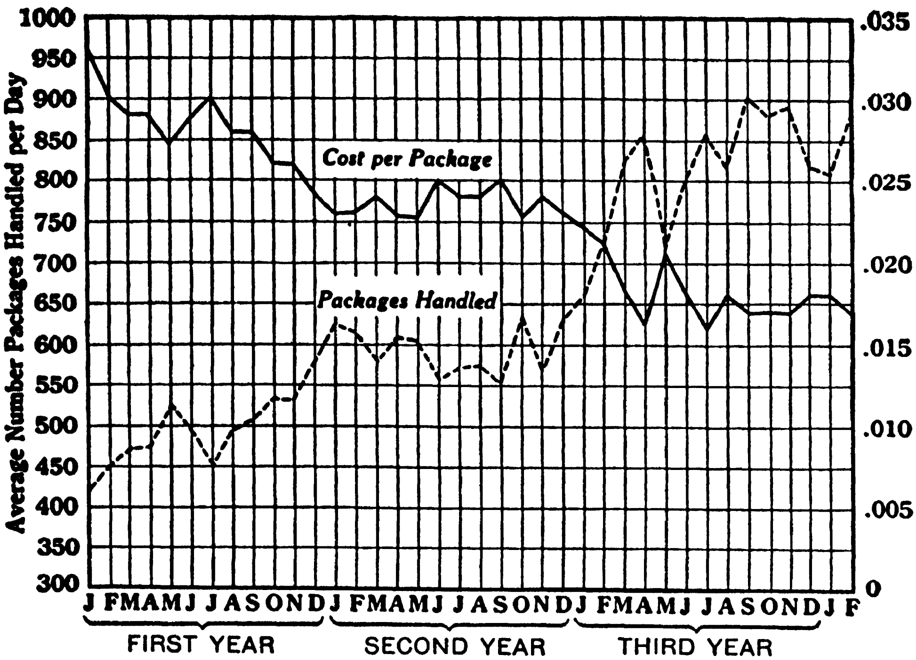


Figure 90. Results of Plan for Factory Trucking

Other groups are obliged to operate either flat or hoist trucks, the time of delivery for which is different. The N item is, therefore, broken down as follows:

$$\text{Hours allowed} = H_a + .25\,(.46\,N_f + .317\,N_h - H_a)$$

where N_f = Number of deliveries made by flat truck (.46 hrs. per delivery)

N_h = Number of deliveries made by hoist truck (.317 hrs. per delivery)

These incentives have resulted in better coordination of work to keep up full capacity, the use of telephones to keep the dispatcher perfectly informed, and other manifestations of cooperation. The

curves (Figure 90) of unit cost and numbers of units handled in one of these cases show the distinct success of the incentive.

Group Task Expressed in Terms of Budgeted Expense.—Where it seems impractical to determine tasks in terms of production units, it is possible to secure a rough equivalent in terms of expense. The actual expense of the operations over a period of at least ten years is used as a guide and an amount in dollars is budgeted which is a little under that of the best previous year. This amount of expense is set up as a bogie and used as a group or departmental task. The premiums are arranged in advance, usually in some per cent of savings relative to the bogie. As this per cent of saving or factor is determined for each group, the individual prorated share of it is increased whenever there is a reduction of numbers in the group. The shipbuilding and drydock company already cited began applying this plan to their material transfer group, extending it to the storekeeping group. The annual premiums amount to $30,000 and the annual net savings come to about $80,000. One of the main claims for this plan is that it facilitates employee and foreman training. It is obvious that this plan is for indirect production, what the standard cost incentive plan is for direct production.

Incentives for Loading and Unloading Coal.—Here again, we meet a varying combination of conditions which cannot be reduced to an ideal task. The size of car varies. The stock pile may be high or low. The cars may be on parallel tracks or on the same track. The weighted factor is used to equalize the results but the method of calculation may involve a table form as well as an algebraic formula. In this case the columns are lettered so that they may be represented by letters in the formulas.

Example of Forms Used.[6]—An oil refinery has taken the pains to work out at least a dozen bonus plans to especially fit their various cases. We have no data as to the results of each application but we recommend the principle of special adaptation and we think the printed forms are examples of good practice. The two conditions of car location are put into columns (Figure 91) while the size of car and conditions of the pile are put into rows. The relationship of these quantities is indicated by formula at the head of the sheet and the letters of the formula refer to data in the columns under the formula letters. The size variables are assigned factors

[6] For the refinery from which this case comes, coal handling is probably direct production but, as it is usually indirect production, we have presented the case here.

HEAT, LIGHT & POWER DEPARTMENT
LOADING COAL WITH AMERICAN CRANE

DATE.............

Location		Size of Car	Cars on Parallel Track				Cars on Same Track			
			Crane Hours	No. of Cars	Factor	Base B × C	Crane Hours	No. of Cars	Factor	Base F × G
			A	B	C	D	E	F	G	H
No. 18 B. H. Stock Pile	Normal Stock	50 Ton			.58				.83	
		70 "			.81				1.07	
	Low Stock	50 "			.70				.96	
		70 "			1.00				1.26	
#5 Stock Pile		50 "			.75				.96	
		70 "			1.05				1.26	
#4 Stock Pile		50 "			.62				.94	
		70 "			.87				1.20	
		50 "								
		70 "								
Totals										

Reported for Work.............

Finished Work..................

Operator Worked......Hrs. × .76 = ...

Fireman " ......Hrs. × .52 = ...

Crane #...... Actual Wage

Coal Foreman at #18 Boiler House {Yes / No

WAGE EFFICIENCY........%

PAYS........Premium

APPROVED....................................
Production Clerk

....
Superintendent

....
Time Department

Date......................

Figure 91. Form for Computing Incentives for Loading Coal

which are included on the form. Thus it is a simple matter to make the calculations when the specific quantities are filled in.

Incentives for External Transportation.—The driving of trucks and the piloting of airplanes present in some respects similar problems. Both involve accident hazards, large material responsibility, and operation without close supervision. There are so many factors involved that no two plans of payment are identical. The factors which count most in a given case should be selected and the others ignored except for special training. Weather is still the great unknown, and standards must be flexible. Sometimes the main consideration is the idleness factor because of the large investment charge. All trucks should be equipped with hubometers and preferably with service recorders. The latter instrument gives a graphic record of running and idle time. Where several types of trucks are used, it is necessary to set up different conditions for each group and, if the number of trucks is large, it may be convenient to apply the incentive by groups. Similarly, pilots on connecting air routes may have a group bonus for the completion of a relay schedule.

Example of Plan for Light Trucking.[7]—The simplest form of truck driver's incentive is the plan of a Canadian retail store which uses the number of parcels delivered as a base. A quota such as 300 parcels per day is established. For every parcel above this standard, the driver is paid a premium of $.04. The result of this has been an increase of 26% in deliveries for the same force and equipment. During the holiday month, drivers have made large extra earnings and smaller amounts of extra earning every week.

Example of Plan for Heavy Trucking.—A meat packing company distributes to the whole vicinity of New York City. The standard for mileage per gallon of gasoline varies between the groups. The difference between the standard and the actual is called "gas saved" and the individual driver receives half the value of this item. He must, however, have driven his truck the entire period without avoidable accident and have been on the job all but two days of the month. If a driver's regular car is out of service and he drives another car part of the period, he should be paid the full premium corresponding to the car driven the majority of the time. If a driver is absent more than the given number of days, any premium due him will be prorated according to the days he is present. Besides the gasoline premium, a bonus of one dollar per period is paid each

[7] *American Academy of Political and Social Science*, Vol. C., No. 189, also *Retailing*, December 28, 1929.

driver who avoids the breaking of a spring. If there is an accident which seems to have been avoidable, the driver will receive no premium or bonus whatever for the period. For one month the total mileage was 7,463 miles for a group of seven drivers. The saving over the standard miles per gallon of gasoline was 422 gallons. At an average cost of $.20 per gallon, the net saving was $84.40. Figuring the premium on the (50-50) sharing basis, $42.20 was split to give $6.03 to each. The miles-per-gallon standard is subject to change with the seasons and also with any change in equipment.

Example of Trucking Accident Bonus Plan.—A midwest merchandising company applies a bonus plan to its fifty-two drivers and helpers which is virtually an incentive against accidents. For each month or fraction of a month over two weeks, a fund of $10 per driver and $5 per helper is set aside and paid annually minus certain deductions. The recipient must be continually employed. There is a committee which reviews evidence and decides on the merit of each accident. The schedule of deductions is shown in Table 67. It is claimed by the management that accidents have been reduced one-half and that the better employees are restrained from quitting. The clerical work amounts to about six hours work of a single man per month.

TABLE 67. DEDUCTIONS FOR ACCIDENTS

(a) Accident causing damage to property	$ 5.00 to 10.00
(b) Accident causing injury to person	10.00
(c) Failure to report an accident, no matter how trivial	25.00
(d) Inefficient service	2.00
(e) Discourtesy	2.00 to 5.00
(f) Unauthorized driving of car	5.00
(g) Smoking on car or while on duty	2.00
(h) Carrying unauthorized passengers	2.00
(i) Merchandise lost. One-half the retail price of merchandise lost will be deducted from bonus	

Incentives for Repair and Maintenance of Equipment.—Mr. Parkhurst says: "Maintenance departments can maintain the same high job efficiencies realized in connection with other types of work . . . a weekly efficiency of from 90% to 100%."[8] He gives as example of this a case of 40% reduction in the labor cost of maintenance. Certainly an efficient maintenance department is most important to the success of incentives in production departments and can increase task standards throughout a plant. This is evident in con-

[8] *Manufacturing Industries*, Vol. XIV, No. 6. In this article the Parkhurst plan is applied to maintenance. See also *Management and Administration*, Vol. VIII, No. 3; *Maintenance Engineering*, April, July, August, and September, 1931; S. I. E. Bulletin, Vol. 3, No. 4; *Factory*, Vol. 78, Nos. 10 and 12; Vol. 98, No. 3; Vol. 99, No. 1.

tinuous process manufacturing but is not always appreciated elsewhere. Any incentive may be applied after some kind of job standard is established, but the incentive must be made to encourage the elimination of needless repair as well as to expedite needed repair. Maintenance groups known as "production" or "assigned" maintenance, repair and maintenance crews are specifically and permanently assigned to certain pieces of equipment, or certain departments, and "indirect" standards can be established as to:

Actual preventative maintenance work normally expected.
Losses of time and production due to breakdowns and repairs.
Production while equipment is in operation.
Cost of repairs.

The incentive plan applied to such groups must be designed to promote preventative action and maximum production within definite cost limits. The ideal would be to have such maintenance that there would be no breakdowns to repair.

Variable Sharing Applied to Reduction of Delays.—The allotment of definite maintenance responsibility to each man in this department is in itself effective and has been known to reduce the volume of breakdown repair 66% and at the same time reduce production delays 80%. With the reduction of these delays as a basis for remuneration, L. Leighton Farrar proposes the following modification of the Rowan premium plan:[9]

$$\text{Earning} = \frac{\text{Time}}{\text{Wages}} + \frac{\text{Per cent Saving in Idle Time}}{\text{Per cent Standard Idle Time}} \times \frac{\text{Time}}{\text{Wages}}$$

$$E = H_a R_h + \qquad \frac{h_s - h_a}{h_s} \qquad H_a R_h$$

$$E = H_a R_h \left(1 + \frac{h_s - h_a}{h_s}\right)$$

$$E = H_a R_h \left(2 - \frac{h_a}{h_s}\right)$$

Key .o Additional Symbols

h_s = Per cent of standard idle time to standard time

$$= \frac{\text{Old idle time}}{\text{Old standard time}}$$

h_a = Per cent of actual idle time to standard time

$$= \frac{\text{New idle time}}{\text{New standard time}}$$

[9] *Manufacturing Industries*, Vol. XVI, No. 5.

ILLUSTRATION:

Old standard time	=	1,000 hrs.
Old idle time	=	300 hrs.
New idle time	=	165 hrs.
New standard time	=	1,100 hrs.

$$h_s = \frac{300}{1{,}000} = 30\% \qquad h_a = \frac{165}{1{,}100} = 15\%$$

$$\frac{h_s - h_a}{h_s} = \frac{30 - 15}{30} = 50\% \text{ (making total wage } 1.50\, H_a\, R_h)$$

In practice this premium will vary between 30% and 80%.

Bedaux Plan Applied to General Maintenance.[10]—General maintenance work is of a basically different nature, in that the workers involved have no direct influence on production and no control over the amount and nature of the work done. The Bedaux Company started to cover general maintenance work in the early twenties. These early applications were virtually budgeted expense controls and were based on the volume of production. As years went by and conditions changed, these applications had to be adjusted periodically. The cost reductions obtained were generally satisfactory but applications proved inadequate for positive control. In 1928, at the instance of a large mid-west client, the Bedaux Company undertook to cover such operations with direct standards. This procedure was slow and costly and justified only because of the large payrolls involved and because of the results already secured on production operations. The results, although slow to materialize, were eventually large, and subsequent refinements and experiences elsewhere have finally given a practical workable practice, readily applicable and generally very profitable. The following refers specifically to nonrepetitive repairs where the work to be done cannot be definitely known in advance.

The general advantages of a direct application are:

1. The control is much more positive. Sudden or unforeseen changes in maintenance programs are automatically considered. Necessary or desirable repairs can be made at the most favorable time and at minimum cost without the handicaps of budgets based on production.
2. The incentive is much more effective because the labor standards are more accurate and dependable. Workers are paid in direct

[10] Courtesy of Albert Raymond, President of the Chas. E. Bedaux Company.

relation to the work done and their wages are not affected by conditions over which they have no control.

3. More accurate estimating, planning, and scheduling are possible.

Classification and Character of General Maintenance.—General maintenance and repair operations with direct time or cost standards can be divided into three general classifications:

1. Repetitive work on standard parts or pieces of equipment.
2. Nonrepetitive work of a definite nature.
3. Nonrepetitive work of an indefinite nature.

1. The first classification covers such things as periodical lubrication and inspection of machinery, replacements, or standard parts, etc. Establishment of standards on such work is similar to usual procedure on production operations, namely:

(a) Define and specify the work to be done.
(b) Establish the most economical procedure.
(c) Determine corresponding standards by study and analysis.

Just as in the case of production work these standards are built up from basic standard elements as much as possible.

2. The second classification covers most of the new construction and installation work, connected with buildings and equipment for which blueprints and specifications are available, and repair work where the exact nature of the work to be done is known and specified in advance. Because of the nonrepetitive nature of the work · becomes necessary to analyze such work:

(a) By class—carpenters, machine shop, structural, pipe fitting, electrical, etc.
(b) By operation within each class, for example: cutting, threading, erecting, insulating, etc., for the pipe fitting class.
(c) By factors of sizes, shapes, weights, location specification, other characteristics, for each operation in each class.

Elementary standard values are then built up in table and chart forms to fit each above subdivision for the entire range of sizes and other characteristics and without reference to any particular job. This demands studies on a sufficiently wide variety of jobs and conditions so that constant and variable factors and their trends can be determined in each case. It is then possible to build all standards of the necessary shop fabrication and all standards of erection according to the known factors of size characteristics, location, etc.. and this can be done in advance of the work.

3. The third, and obviously the most complex situation, is that of repair work where it is impossible to know definitely in advance what work is to be done and how this work will be done. It is a case of expecting to patch a roof and finding that the roof structure itself needs repair, of planning to replace a gasket on a steam line and finding that the flange and insulation need replacement, of expecting a small partial part replacement and finding the whole piece of equipment in need of repair, etc.

Because the extent and nature of the work are not known in advance, it is obviously impossible to establish *in advance* a truly fair, reasonably accurate standard for the entire job. The usual practice of estimating the job is subject to considerable error and where used at all must allow for subsequent adjustments that may defeat the intended purpose of accurate and positive control and proper compensation. The practical answer is to record the work done either after or as it is being done, on the basis of "elements" similar to those established for class 2, by size, characteristics, location, etc. With pre-established basic data based upon the same elements of work it is possible to select the standard corresponding to each element and then group these elements to correspond to work done.

Basic Data and Clerical Procedures.—Because of the immense variety in operations, sizes, conditions, locations, etc., the basic data thus required are correspondingly extensive and must be accumulated over a period of years, and well checked to permit coverage of all new situations. In recent applications of the Chas. E. Bedaux Company it is claimed that 65% to 85% of the work was satisfactorily covered without new studies being necessary other than some occasional checks, while 90% or more of all maintenance and repair work was eventually covered by direct standards. The checking of work and operations required by this procedure whether during or after performance must be reliable and calls for periodical visual observations by the foreman, the inspector, or by special checkers, all of whom must be familiar with the type of work involved and with the basis of standards set up. As the elements and fractional operations are performed the checker lists same and applies the corresponding credits from the available standard basic data so that at the end of the job, only a tabulation of these elementary credits is required to give the total standard for the job.

When the time control is used as a basis of compensation the basic period for premium calculation is usually the pay period. The build-up of standards from elements permits a split-up of jobs uncompleted at the end of each pay period. The usual 60 B hour is

the task for all concerned and the usual premiums are paid for all B's above that. The checking practice can be greatly simplified by use of standard forms, listing all possible elements or fractional operations, from which those actually required can be checked off. This and proper training of checkers has reduced the original total clerical expense covering time study, checking and recording of work, standard tabulation, timekeeping, control sheets, and payroll calculations, from an average of 6% of the payrolls involved, to 2% to 4% according to type of maintenance, area, and size of payroll.

Results Claimed by Bedaux Executives.—Increases in productivity up to and over 100% have been frequent with resulting net cost reductions up to 40%, and increased wage compensation up to 30%. A large part, if not most, of the improvements come from improved facilities and better planning and scheduling of the work rather than from increased speed of performance. The standards are accurate enough in each case to make the worker feel a fair relationship between pay and work done. In one typical case the superintendent of a production department used to ask the master mechanic for "a couple of plumbers to look over some defective piping." A pipe fitter and a helper would go to investigate, the helper would return to the pipe shop for tools and supplies, sometimes a quarter of a mile away, while the pipe fitter waited. Now the master mechanic inquires into the nature of the trouble and then sends one or two men, as need be, with all required tools and supplies. The standard data show the most economical way of performing the work and emphasize nonproductive elements, such as walking to and from jobs, leading to better scheduling.

Empiric Scale for Emergency Work.—An eastern asphalt company has used a special incentive for cleaning cracking chamber of stills which is adaptable to many emergency jobs. Before the plan was devised, it took between 30 and 40 hours to clean coke from the inside walls of the still. The hardness as well as the quantity of coke to be removed varied. The cleaning had to be done three times a month, on a Sunday or holiday, and, unless hours intervened, work was uncomfortable because of the heat. It was impossible to standardize all conditions and to establish an accurate task time which could hold at all times. On the other hand, the management believed that an average of $250 could be saved each time, if the men would do their best. The company was, therefore, willing to offer the group a premium varying up to $130. This premium was scaled empirically against hours saved by the group (Figure 92). The rate of increase was changed slightly to compensate the increas-

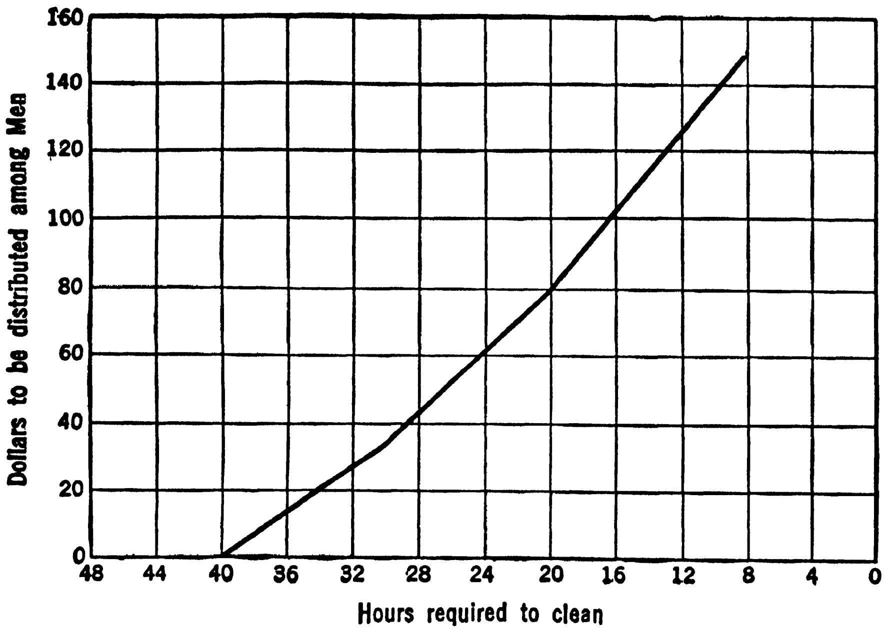


Figure 92. Premium for Cleaning Cracking Chamber of Still

TABLE 68. PREMIUM FOR CLEANING CRACKING CHAMBER OF STILL

No. of Hours	Dollars to Group	No. of Hours	Dollars to Group	No. of Hours	Dollars to Group
12.0	130.00	21.5	73.25	31.0	31.50
12.5	126.87	22.0	71.00	31.5	29.75
13.0	123.74	22.5	68.75	32.0	28.00
13.5	120.62	23.0	66.50	32.5	26.25
14.0	117.49	23.5	64.25	33.0	24.50
14.5	114.37	24.0	62.00	33.5	22.75
15.0	111.24	24.5	59.75	34.0	21.00
15.5	108.12	25.0	57.50	34.5	19.25
16.0	104.99	25.5	55.25	35.0	17.50
16.5	101.86	26.0	53.00	35.5	15.75
17.0	98.74	26.5	50.75	36.0	14.00
17.5	95.62	27.0	48.50	36.5	12.25
18.0	92.50	27.5	46.25	37.0	10.50
18.5	89.37	28.0	44.00	37.5	8.75
19.0	86.24	28.5	41.75	38.0	7.00
19.5	83.12	29.0	39.50	38.5	5.25
20.0	80.00	29.5	37.25	39.0	3.50
20.5	77.75	30.0	35.00	39.5	1.75
21.0	75.50	30.5	33.25	40.0	0.00

ing effort and discomfort, because it was found that the men would buckle in to the work even before the furnace was reasonably cooled. The details of the plan follow:

The group of workers to do the cleaning will be 2 gangs of 4 men each.

The work will be divided as equally as possible between the 2 gangs, i.e., if in the judgment of the superintendent the cleaning work will require 16 hours, then each gang will work 8 hours.

The men will get their hourly wages, with overtime and Sunday rates same as before.

In addition they get a premium, the amount of which depends on the time taken to clean. (See Table 68.)

The time taken to clean shall start when heads are off the chamber and end when all coke is out of chamber and off the roof and platforms. This time is to run continuously, no deduction being made for lunch hour or other time not actually worked by the men, except when work is interrupted by unavoidable accidents like fires (other than fire in chamber). These delays will be recorded to the nearest half-hour.

Coke fires must be kept low or out.

The premium will be divided among the individual men in proportion to the time actually worked by each man as compared with the total hours worked by all of them. (Use actual hours disregarding overtime-hours, if any.) For example:

Heads off chamber Tues. 6:00 P.M.	
All coke out of chamber Wed. 12 noon	
Elapsed time	18.00 hrs.
	1.00 hr. delay due to fire
Actual cleaning time	17.00 hrs.

Individual man-hours

Gang #1	Man A	8 Hrs.	Day rate	
	" B	8 "	" "	
	" C	8 "	" "	
	" D	8 "	" "	
Gang #2	Man E	8 Hrs.	Day rate	2 hrs. Overtime
	" F	8 "	" "	2 " "
	" G	8 "	" "	2 " "
	" H	8 "	" "	2 " "

Work interrupted by fire for 1 hr. between 9:15 and 10:15 A.M. Wed.

Men in Gang #1 will get paid for 8 hrs. @ .55¢
" " " "2 " " " " 11 " @ .55¢

Total number of man-hours devoted to actual cleaning 8(4) + 9(4) = 68 man-hours
Premium at 17 = \$98.74
Premium per man-hour = 1.45¢
Men in Gang #1 will earn during this period 8(.55) + 8(1.45) = \$16.00
" " " #2 " " " " " 11(.55) + 9(1.45) = \$19.10

Incentives for Window Washing and Janitor Work.—Such work as this is sometimes controlled by separate departments and sometimes it is centralized as a branch of maintenance. In the former case, the part of it related to production such as removing waste from machines may be included in a production group and the janitor allowed to share the group incentive. More often, it must be treated separately. If it is not centralized, no one thinks it sufficiently important to check. If it is centralized, it is a simple matter to establish time standards per window pane of given size, per unit floor or wall area, etc.[11] There may also be a relation between some of this work and departmental efficiency, in which case standards, instructions, and incentives will be particularly worth the trouble. In large organizations, much of this work will usually be functionalized and graded. This is done partly to allow the use of various job titles and rates. If properly done, it will minimize the amount of servility which tends to accompany the lower types of janitor work.

The psychology of this grading is as important here as anywhere else. It has also been suggested as a hopeful solution for the domestic servant problem. Paying by the number of standard hours accomplished, regardless of actual time, is one of the most effective incentives and simple enough for any unschooled man to comprehend. One company cites a case of a cleaning job which cost $16 under this plan and $106 previously under day wages.[12]

Incentives for Inspection.—If there is any kind of work in a factory which may seem too sacred for financial incentives, it is inspection work. Yet certain kinds of inspection have been timed and given bonuses since the later days of Taylor. At first this only included mass work such as the inspection of balls for ball bearings where each inspection was like any other job in the sequence and where little judgment was involved. As mass production spread it was found that even where inspection was intermittent the inspection time bore a definite relation to direct production time. It has become evident, therefore, that tasks can be established and incentives paid for inspection wherever the scale of production is large enough to justify the cost of task determination.[13]

An electric appliance company has[14] determined this ratio from past records, has reduced the allowed time 45% from this, and has paid a 1% premium for every 1% reduction below the allowed

[11] Similar standards are set for painting. See *Factory*, Vol. 99, No. 6.
[12] A. M. A. Production Executive Series No. 21, also *Factory*, Vol. 95, No. 3.
[13] "A Case of Job-Shop," *Factory*, Vol. 95, No. 5.
[14] A. M. A. Production Executive Series No. 22.

time. In other words, it has put inspection on piece rate. As a quality incentive may deduct from piece rate, so the "rework" cost is deducted from the 100% earnings saved. Quality standards must be especially stressed. The passing of defective work is caught by subsequent operators except for final assembly. In that case it is necessary to use two "overinspectors." Even the last-named operators are paid a premium on the number of errors detected and the errors are charged back on the employees responsible. Frequently, random inspection is sufficient for the overinspection as it is, in fact, for many interoperation inspections also. These premiums are usually allotted by groups and paid monthly. The main prerequisite for any inspection incentive is a complete set of standards for quality. (See also Incentives for Quality, Chapter 17.)

Miscellaneous Applications.—The three aristocratic machine trades—toolmaking, die sinking, and patternmaking, also drafting—have occasionally been put on incentive.[15] The task is usually estimated from the records of similar work already done. Unless these records are subdivided by functional elements the resulting tasks are crude and may not be much good. In large companies where such skilled work is highly specialized the work assignments are narrowed and the records are somewhat better. Where the work is done by a group it is simpler to set up the tasks, hence much of the incentive work in this field is by group application. What is needed is an accumulation of best records by functional divisions, the smaller the divisions the better. This takes years and costs money but with soaring time rates it would pay to invest in this direction. Better yet the skilled trades should be analyzed continually throughout the dull period of the business cycle when the time study men are under less pressure. Then the data would be ready for use when most needed. It would also increase the accuracy of time and cost estimates. The potential savings per labor-dollar are higher here than in most other kinds of work; in fact, the man-hour saving alone is so important that it ought to arouse more management interest in this last frontier for wage incentives.

[15] *American Machinist*, August 2, 1928, November 19, 1931, and March 21, 1936; *Factory*, Vol. 95, No. 7.

CHAPTER 19

INCENTIVES FOR OFFICE EMPLOYEES, SUPERVISORS, AND EXECUTIVES

> But as for men, they maye be well perswaded and brought to obedience, if a man wyll shewe them, howe it shall be for theyr profyte—and thus, whan ye have ones ingendred this affection in a man, that he oweth you good wyl,—that he wyll applie his mynde and diligence to do even as ye wold your selfe; and beside that, ye have gotten him the science, howe every worke that is done shal be most profitable,—such a man shuld be a very good and a profitable stewarde and deputie.—XENOPHON, 4th Century B.C., Translation of 1500.

The Office Problem.—"Wage" incentives were not extensively readapted to office work much before 1923. In fact, every one said it simply could not be done. Nevertheless, some 5% of the large companies have now applied incentives to typists, key-punch operators, etc., and 11% have done so to billing and order clerks. This has become necessary because the proportion of office work to shop work has increased. Office work includes such jobs as: typing—shop orders, invoices, transcriptions, labels, inspection orders, etc.; operating—tabulating machines, comptometers, addressographs, etc.; checking shipping lists, billing, circularizing, filing, folding, mail handling, messenger work, bookkeeping, cashiering, telephone switching, etc., as well as general secretarial work and supervision. There have come to be about 1,300 distinct office jobs, not counting technical desk positions. Furthermore, the number of clerical employees in the United States is said to have increased seventeen-fold in fifty years. Although the use of machines in office work is increasing, they are as yet less predominant there than in factory work and are of such nature that they cannot set the pace. As a rule, clerical jobs do require more individual variation and consequent choice of action. The psychological aspect of office remuneration is also especially important. For these reasons, factory experience in incentives must be followed with some precaution, but it can be followed. Job evaluation may be called salary standardization, and tasks may be called quotas, but the principles remain the same. Opposition ceases as soon as results are seen. In fact, some companies now have over

70% of their accounting departments on incentives. As an example of results, the output of invoices per operator per day in one company has increased from 250 to 350.

Job Standardization in the Office.—Much has been written on what is called salary standardization,[1] that is, the analysis of job elements and characteristics, the classification and pricing of jobs by grades, the adaptation of proper incentives, the charting of promotion paths, and the periodic consideration of grade readjustments. The carrying out of this program varies from crude estimates of quantity and quality standards to minute specifications of every single function. An example of the first procedure is the use of an index of the total volume of work, such as the volume of checks written in a cashier's office. The quality may be estimated by the percentage of errors made in the same or in some other work where a count is possible. Similarly, the number of postings, invoices, letters, or tabulating cards may be used as the index. The proportionate volume is then used as a task measure and a bonus may be set. As much as 18% improvement in production has been secured from this crude procedure.

The other procedure is represented by paying typists in proportion to the number of keys struck.[2] A cyclometer is put on the back of each typewriter and every stroke is recorded. Four 6-inch lines, or 240 strokes, is called a point of credit. At the end of the day these points are added for each operator. If 600 points are exceeded, 1½ cents per point above the task is paid in addition to the salary. The latter may vary according to the experience of the individual without changing the premium rate. Also, 1,400 square inches of typed space has been used as a task unit; one-third of a cent is paid for every square inch over 1,400.[3] It will readily be seen that for statistical work or for indented quotations, the number of lines is not a true measure of effort. On the other hand, most work will average out well enough to permit the use of lines, and that is far simpler. The real question of policy is how far to go in grouping jobs into like types. Some companies think it sufficient to have relatively few groups of job types, and others think it necessary to standardize nearly every individual job to suit special variations. Either extreme should be avoided. Most difficult of all to standardize is the general clerical job in which the employee is changing frequently from one set of functions to another. This latter class of jobs is not being put on incentive plans very rapidly. A literature is

1 See Chapter 1.
2 Metropolitan Life Insurance Co. Method of Compensation No. 4; also *Administration*, Vol. 5, Nos. 3-7.
3 Kardex Institute, Special Research Report, 1927.

developing, however, in this field of work. It is mostly sound and surprisingly specific.[4]

Incentive Plan Best Suited to Office Work.—Straight salaries persist in this work for much the same reasons that straight time wages persist in factory indirect production.[5] Similarly, they fail to get the best results. The easiest improvement is an announced plan of salary grades encouraging each individual to work for the next higher grade. This is like the differential time plan, the success of which is great or little depending on the thoroughness of the performance rating and the frequency of the regrading. Performance rating cannot amount to much unless the job elements are carefully measured. When that is done, any other incentive plan may be selected.

Commission, that is, piece rate on the standard hour basis, is the next simplest plan and is decidedly effective if guaranteed.[6] On the other hand, the likelihood of change in functions which characterizes many office situations gives straight commission a good deal of uncertainty which is not due to any fault of the employee. Accommodation to change of work and the versatility needed for it should be rewarded, not penalized. The least we can do in this direction is to guarantee a low salary and put the real incentive on top of it. By this we mean the small amount per unit for units produced in addition to task. There are usually several of these for as many zones of extra production. The step bonuses should increase in size because the overhead charge per unit will decrease as the successive zones are attained. In one department store the task for billing is 7,500 bills per month. A scale of additional amounts and bonuses is in force ranging up to work above 10,000 bills. This final bonus is $.75 per 100 bills. Sometimes a penalty is deducted per error but the base salary is usually guaranteed. W. H. Leffingwell[7] used an empiric scale in which the bonus begins at 67% of high task, increases gradually to 89% task and then increases two points per one point of efficiency until 100% task is reached at which position it amounts to 50% of the base salary. Thereafter the (100, 150) piece rate is paid.

[4] A. M. A. Office Executive Series Nos. 9, 17, 18, 25, 27, 29, 32, 33, 34, 35, and 44. A. M. A. Financial Executive Series Nos. 11, 12—Survey Report No. 16. *Taylor Society Bulletin*, Vol. XIII, No. 4. S. I. E. Springfield Convention Report, Vol. 4, No. 6; *Management*, Vol. XXXI, No. 2. For Training: A. M. A. Office Executive Series No. 6 and National Personnel Association, Reports of Committee on Office Work Training. For a study of fatigue in stenography, see *Management Division Quarterly*, Man. 50. Also Classification and Compensation Plans, Civil Service Assembly of the U. S. and Canada and the Bureau of Public Personnel Administration

[5] See "Ten Year Survey of Salaries," *The Industrial Bulletin*, November, 1933, and the October tabulations of the N. Y. State Department of Labor.

[6] For application to messenger service, see L. Galloway, *Office Management*.

[7] W. H. Leffingwell, *Office Management*.

TABLE 69. TYPING STANDARDS FOR PIECE WORK PLAN

GENERAL PRODUCTION

A standard line is 60 strokes or 6 inches of typing on a "pica" type machine and 5 inches on an "elite" type.

Work that can be measured by the line is paid for at the rate of one-half cent per line.

Line Allowance

In re	1 line
If over two lines, a credit is allowed for each 6 inches of typing of	1 line
Date, Address, Salutation, and Closing	3 lines
Last line of Paragraph:	
If it measures more than one-half line	1 line
If it measures less than one-half line	no credit
Envelope	2 lines
Filing Tags:	
Heading and Closing	3 lines
For each 3 lines written	2 lines
Tabulation:	
For each line written	1 line
If in excess of 9 lines and more than 2 columns, additional credit for each line	1 line

Allowance for Forms

For each line of insertion on printed form	1 line
The minimum credit for completion of printed form	3 lines

Legal Forms

For each dictated line	2 lines

Carbon Copies

For each additional carbon copy, credit of	1 line

Example of Plan for Stenographers.—A large insurance company has found it worth while to set up thorough job standards for dictaphone stenographers.[8] These typists are centralized in a single group. The beginners are given instruction and paid the salary of their previous grade for four weeks plus any piece work amount their production may exceed task. Thereafter the salary guarantee is removed. The piece rate arrangement is shown by Table 69. Work which is difficult to measure by the line is classed as "special work." Payment for special work is based on the average production of a phonographer, as would be represented in the average number of lines per hour credited to the phonographer over a period of one month. The month's work used for the purpose of allowing this credit is, generally speaking, that month prior to the semi-annual rating of all phonographers. On the theory that the phonographer is not entitled to compensation on the piece work basis when not actually producing, "special time" is allowed for time lost because of no work, machine repair, or time spent in the medical division, and payment for special time based on the salary of a grade 6 clerk, with a minimum and maximum per week, dependent upon rating and length of service. Compensation paid to a phonographer during her vacation is based on her average weekly earnings received during the three calendar months preceding vacation. During absence due to any other cause, the phonographer is treated as a grade 6 clerk.

Guaranteed Salary.—A clerk transferred to the position of phonographer receives for a period of four weeks, subject to general rules relating to attendance, the same amount of salary received in her former position in the office. Upon completion of this period of four weeks, if her earnings are in excess of the amount paid, the difference is paid to her in addition to salary received for the fifth week. Because the payroll for the entire office is made up early in the week, and since the earnings of the phonographer for that week could not be determined until the end of the week and paid as salary for the following week, the amount she receives as regular salary, exclusive of such amount as is referred to in the foregoing sentence, is recognized as an advance. The phonographer signs an agreement to the effect that should she be transferred to another position or leave the services of the company, this amount would be deducted from her earnings for the last week of service as a piece worker. Some typists have risen from $25 to $45 a week and the costs are less. The cost per average business letter is about $.13, including stationery and postage but excluding the time of the dictator.

[8] A. M. A. Office Executive Series No. 11.

Incentives for Supervisors

Simple Direct Measurement Plan for Supervisors.—It is maintained by a few that foremen will do their duty as well on straight salary, as on salary and bonus. Experience indicates, however, that foremen have more freedom as well as more interest when on a bonus. This is because many managers feel obliged to use driving methods in dealing with foremen not on any bonus, but do not feel so obliged when they are on some bonus plan. The simplest incentive plan for foremen is one which pays a weekly bonus on the number of standard hours of work accomplished within the group plus one other element such as fulfilment of delivery promises. The per cents of bonus are empirically scaled with the standard hours and delays. The first bonus may be 10% of salary when the average efficiency of the group is 80% and average delays less than 12%.[9] The maximum per cent of salary may be 35% when the average efficiency of the group reaches 110% and average delays are less than 5%. This is easy to understand and sufficiently generous to get internal results but it has not always proved satisfactory. The emphasis on the quantity produced internally may work against interdepartmental cooperation. Foremen paid this way are reluctant to transfer or lend operators, are likely to quarrel with other foremen, and at best, are inclined to ignore the needs of the plant as a whole. Gantt restricted his foreman bonus to man-hours above task in order to emphasize the training of efficient operators.

Wide Choice of Performance Factors.—Among the various schemes actually in use for foreman incentive, the following performance factors, some of which are indirectly measured, are included:

(a) Weighted factors for controllable, and semi-controllable expenses, such as excess labor and overtime, unearned pay or work below task, extra supervision, spoiled work—excess of materials or supplies.

(b) Budgeted allowances for indirect labor, direct labor, raw materials, expense materials or supplies, severity and frequency accident rates, repair, heat, power, and water.

(c) Weighted factors for regular attendance, labor turnover, training of new employees, rejected work, material waste, and idle machinery.

(d) Weighted factors for unit labor cost, percentage of scrap, percentage of shipments on schedule, uniformity of quality as shown by low percentage of complaints.

[9] *Management Engineering,* Vol. 2, No. 5.

(e) Factors for dispatch in executing orders, cooperation with others, handling labor, punctuality, department appearance.
(f) Tonnage, no accidents, and good housekeeping.
(g) Ratio of total labor costs to total factory costs.
(h) Standards in per cent of the sales dollar, etc.
(i) Savings from reduced overhead per unit of product.

The most popular choice is the simple combination of cost control and quality control, the former carrying a weight of 75% and the latter 25% of the combined task. Bonuses begin when 70% of the task is achieved and rise to a maximum of 25% of salary when full task is attained. The average bonus earned is reported to be around 13% of salary.

The choice of performance factors depends on local and perhaps on temporary conditions. As in all other incentive plans, the object is to select and weight the factors so that the foreman will automatically emphasize the performances most in need of attention. Foremen of "nonproductive" departments may be paid on the same factors used for foremen of "productive" departments provided the time of such work is standardized in terms of allowed hours per unit of production. Standards if directly measurable should be carefully determined so that there will be no necessity of altering them hurriedly. The highest potential bonus in per cent of salary which we have discovered is 50%.

Standardization of the Foreman's Job.—Since some phases of foremanship may be *measured* while other phases such as cooperation may be only *graded,* it is necessary to define these terms as they apply to the foreman's job.[10]

"Measuring: There are certain characteristics bearing upon the qualifications of a supervisor which may be definitely ascertained and measured. These characteristics concern mainly the tangible elements of his work. We can thus measure in definite units a man's attendance, the quantity and quality of production under his supervision, relative cost, and some other factors having to do with his performance and efficiency. Systematic recording of these tangible factors is what the committee means by 'measuring.'

"Grading: There are important but less tangible characteristics which cannot be definitely measured. These characteristics include character, personality, leadership, capacity for development, and other items which must be judged mainly by opinion. These characteristics are included in this report under the term 'grading.'"

10 A. M. A. Production Executive Series No. 26.

With this distinction in mind, some able executive or leader of foremen should study each foreman's job. This cannot be done by merely timing. It requires joint analysis by the leader and each foreman. At best, the job can only be roughed out or outlined, but that much should be put into written form. In this way, the various duties may be weighted according to their importance and used as a basis for individual instruction. Complete cost reports, records of power consumed by equipment, facts regarding the business as a whole, are helpful in explaining the relationship between performance and results.[11] Frequently, a weekly or monthly class in foreman training is worth the trouble and may be given on company time. A bonus is never properly arranged without job study and is only partly successful without job training. Since increased thoughtfulness and interest are among the main purposes of an incentive, these matters must be fulfilled with particular care where foremen are concerned.

General Requirements for a Thoroughgoing Plan.—

1. The plan should be guaranteed a year ahead and not changed merely because a good foreman makes more than is expected.
2. Results should be measured or graded and the bonus paid weekly in separate envelopes. The bonuses should start at about 15% of salary and advance in proportion to responsibility, ending at 30%-50%.
3. The bonus must encourage: steady, but not necessarily increased production, waste and cost reduction, maintenance of quality, utilization of equipment, and assistance to employees.
4. The bonus must not oppose: change in method or rate, transfer and interdepartmental accommodation.
5. Operation must be fairly simple so that it can be figured with little expense and clearly demonstrated.

While many other accomplishments[12] may be roughly measured, we believe that the ones listed are the main essentials. For instance, any such feature as departmental cleanliness or the ratio of time work hours to bonus work hours may be given special emphasis temporarily. Incentives are particularly important for the supervisors of departments which do not have a large proportion of the employees on some incentive plan. In such cases, there are large potential losses if the supervisors fail to realize their responsibility in the matter of

[11] See *Better Foremanship*, by Glenn Gardiner, McGraw-Hill Book Co., 1941.
[12] Supplemental Bonuses, National Industrial Conference Board, A. M. A. Production Executive Series No. 19.

production and cost control. The report of the A. M. A. Committee on Supervisory Forces will be helpful.[13]

Example of Foreman Bonus Plan.[14]—While it may not be desirable to restrict bonuses entirely to achievements which are measurable, it is at least essential to include some of the major achievements which are measurable, and, for the sake of simplicity, add only one or two of the others. An arbitrary rule has been suggested that the measurable part contribute about 80% of the bonus and the graded part 20%. The following plan meets these practical conditions as well as the ideal requirements given above. There are three bonuses: (a) one based on production, (b) one on cost reduction, and (c) one on suggestions. The first two bases are measurable.

(a) The production for the previous year is calculated by weeks. The production for the current year is figured and averaged from the first of the year, and foremen are paid each week a bonus of 1% of their salaries for each 1% increase relative to the previous year.

(b) Every week, the costs on shop orders are completed and given to foremen. The average low unit costs for previous years are taken as standard. The new costs are averaged from the first of the year, and the foremen are paid each week a bonus of 2% of their salaries for each 1% decrease relative to the previous year. This extends up to and including a 5% reduction. Thereafter an additional 1% bonus is paid for each extra 1% reduction of cost.

(c) Under the employee suggestion system, the suggester is paid $1 initially for every suggestion of merit, whether it is eventually used or not. The foremen are given a $.50 bonus for each of these initial payments. Payment is immediate, not periodic.

The cost sheets are for the whole plant and stimulate interest in the achievements of other departments. A competitive feature is thereby introduced, which is no small part of the plan. In this case, the foremen's total salaries amount to only 15% of factory wages, so that the improvements prerequisite to earning the bonuses are several times as large as the bonuses. This obviates any upset of the budget. An outstanding virtue of this plan is that some bonus can be earned in slack times, that is, the bonus on cost reduction may be as large as in busy times. When there is no cost reduction for the week, there is no bonus, but in the long run there are pretty sure to be reductions. Final accumulations not paid weekly are made up after the close of the annual accounting but no penalty is accumulated. One company claims a change in cost efficiency from 68% to 93%.

13 A. M. A. Annual Convention Series No. 26. Also Office Executive Series No. 31.
14 A. M. A. Production Executive Series Nos 15 and 47.

Other Cases in Print.[15]—One highly mechanized company has a plan based mainly on the ratio of service labor and controllable burden of the department to the productive labor of the entire plant. The results are clearly presented like a cost report.

A hosiery company has a plan based on six measurable factors: productivity of direct labor, increase in quality, training of beginners, reduction of indirect labor costs, reduction of time on unstandardized work, and reduction of waste.

A rubber company has an excellent premium plan for supervisors which is an extension of its Bedaux plan for employees.

An axle and spring company has a plan based on the ratio of expenses to production. A sliding average is used so that emphasis is placed on maintaining the reductions.

Incentives for Executives

Two Types of Incentives.—All incentive plans for executives may be classified into two main types according to their parentage. The *general merit* type has evolved from profit sharing plans[16] and at best can only roughly reflect the contribution made by individuals. The *standard accomplishment* type has evolved from production incentive plans for foremen and shows specific connection between performance and reward. Since the American Tobacco Company plan became known in 1911 and the Bethlehem Steel Company plan in 1917 there has been controversy on the whole idea between stockholders and management.[17]

General Merit Plans.—In this category are plans for sharing net earning increases, overhead expense saved and direct expense saved. In these plans there is usually established a common bonus fund.[18] It may be half of the profits remaining after dividends are declared on the preferred and common stocks, or it may be a percentage of salaries set aside at the time dividends are declared. In one automobile company, the fund is determined by setting aside $2 per car on the first 20,000 cars exceeding 50,000, $3 on the next $20,000, $4 on the next, and $5 on the remainder. There is always some minimum standard fixed below which no bonus is merited. It is common

15 *The Iron Age*, Vol. 121, No. 21. A. M. A. Production Executive Series Nos. 48 and 64. *Manufacturing Industries*, Vol. XIV, No. 3, and Vol. XVII, No. 11. *Factory*, Vol. 96, No. 6, and N. I. C. B. Studies in Personnel Policy No. 30.

16 Straight profit sharing plans that make annual awards to all employees, with no attempt to reflect individual performances, may, or may not, add to well-being but they should never be looked upon as incentive plans.

17 *American Business*, July, 1940, reported that nearly one-third of all corporation presidents were receiving some kind of bonus or profit share in addition to annual salaries. For the legal aspects of this problem, see G. T. Washington's, *Corporate Executives' Compensation*, The Ronald Press Co., 1942.

18 A. M. A. General Management Series No. 84.

practice to state this in terms of total earning, but it is better to employ net earnings. If the earning is above the minimum, the bonus may be expressed in per cents of increase. When the company is expanding rapidly, payments may be made in stock, but otherwise it is wiser to make them in cash, and monthly if accounting permits. It is also common to pay partly in cash and partly in stock.

Most of these plans are started as experiments and are at first applied only to a few major executives, such as production manager, chief engineer, head of research, and sales manager. If the experiment proves satisfactory, other staff men and perhaps foremen are included later. Executives are graded according to general merit, that is, the supposed contribution of their work to profits, and the individuals or groups are given shares which vary with this contribution. A small committee assists the president of the company in determining the shares, and together they may promote or demote the executives from one grade to another. Sometimes a length of service plan is combined so that each year increases the percentage of sharing. The grading and its possible realignment intensify the incentive effect. They also introduce dangers but these are not serious if arrangements are announced in advance. The practice of determining individual bonuses arbitrarily and secretly at the end of a year is sometimes defended on the grounds that the contribution of higher executives to profits is intangible and must be judged in a general way. It is not the best practice, however, because it is likely to raise the suspicion of favoritism even when the decisions are just.

Like employee profit sharing, the plan of grading and grouping by contribution indirectly measured is weak as an incentive on account of possible no-profit years during which greater effort may have been exerted than during high profit years. The plan is also weak as the standards of contribution are too general to define either working goals or paths of achievement. It can encourage joint action and is, therefore, suitable for major executives. It may also serve as a temporary expedient while a more thoroughgoing plan is perfected for executives less concerned with general administration. In the latter case it is certainly possible to set up standards for measurement more direct than final profits. For instance, savings relative to budgeted expenditures, increase in sales volume, reduction of unit cost, operating-revenue ratio, and satisfactory personnel relationship, may all be directly measured.

These plans may be again subdivided according to the proportion of bonus to salary. It is well known that Mr. Schwab advocated a low salary together with a high bonus definitely related to profit or cost. He cited the instance of a major executive who preferred to

have no salary provided he could have 1% of the amount net profits exceeded the advance estimate. That executive earned over $1,000,000 as bonus during a single year.[19] Regardless of these policies the plan must be fitted to the organization and not taken over completely from another application.

An Executive Endorses the Plan.—An executive of a mid-west electric company writes:

"Inasmuch as the executive division of any corporation is responsible not only for profits to the stockholders but also is responsible for future operation and new developments in the business, a separate classification and a different standard of incentive should cover this group.

"This group cannot participate in receiving any bonus unless it is successful in a profitable operation. Before this group can receive any bonus, all necessary operating expenses including depreciation are deducted from the gross profit and a liberal amount set aside for common stock dividends. A certain per cent of the remaining net profit is set aside quarterly for distribution among the executives in proportion to their monthly salary. This is a good arrangement as it will make the executive group strive for a better rate of profit and a continuation of increased business. The intention is to make extra compensation directly proportional to the responsibility involved."

Standard Accomplishment Plans.—As the former type of plan begins at the top and extends downward, so this type begins with the operating divisions and extends upward. There are two advantages to this latter approach. Definite standards of accomplishment other than profits may be used as the basis of reward, and the rewards may be charged with indirect expense or overhead. This makes the plan independent of net profit. Where group bonuses are paid direct producers, it is simple to arrange further bonuses for executives on the collective standards. More precise standards for quantity and quality may be arranged if there is in use a common denominator for accomplishment such as the Bedaux, the Dyer unit, or the standard-hour. Not only do foremen participate in the 25% of wages saved under the point plans, but the superintendents and the works manager do also. The proportion of this saving is varied according to contribution or responsibility by the principle of weighting each phase of work. Some companies call this measure of accomplishment "effectiveness." Any means which will provide a relative meas-

19 C. M. Schwab, "The Reward of Management," *Administration*, Vol. 5, No. 5, and Andrew Carnegie, "My 20,000 Partners," also A. M. A. Convention Series No. 71.

ure of departmental efficiency, such as the flow of work and the reduction of cost, will be superior to profits alone as a basis of reward because the latter is somewhat independent of individual effort. The over-all efficiency of the plant is for the same reason the fairest base for an incentive to the works manager and his staff. The test of accomplishment standards is whether or not they provide some guide to the best use of time and money for the individuals concerned.

Accelerating Premium Based on Standard Costs.—If costs are figured variously to correspond to the fields or functions of certain salaried executives then costs may be standardized as measures of effectiveness, particularly for operating and maintenance superintendents, their assistants, general foremen, and other works department heads. A mid-west steel company has recently begun doing this and is paying premiums according to the "cost-efficiency."[20] Standards are applied monthly to each item of controllable costs. The *cost-efficiency* of each department, and of the whole works, are figured for the past six months, dropping the earliest one as a new one is added. The cost-efficiency in per cent is computed by dividing the total standard dollars by the total actual dollars involved in each case. The excess of this percentage over 80% of the standard is squared and divided by 10 to establish the percentage of premium which is to be applied to base salaries.

$$P_r = .10\left(\frac{C_s}{C_a} - .80\right)^2 R_m$$

As soon as the figures can be determined for the preceding month, 50% of the earned premium is paid to each participant. Then six months later, after adjustments have been made, any remaining amount due the participants is paid in full. Since the formula used is that of the parabola the premiums accelerate and above 100% of the standard are very generous indeed. A curve nearly the same as this earning path may be seen in Appendix B (Figure 111). It is pointed out that the cost standards are also used as part of the financial control of the company.

Example of Plan Based on Capacity Use.—A steel casting company has found that its plants begin to make satisfactory profit when capacity use reaches 65% of maximum. For that production, and for successive steps above it, the company offers to pay bonuses as follows:

[20] N. A. C. A. Bulletin, Vol. XXII, No. 17, Sect. 1.

Per Cent of Full Capacity	Bonus in Per Cent of Base Salary
65–70	2
70–75	3
75–80	4
80–85	5
85–90	6
90–95	8 (note acceleration over earlier per cents)
95	12

The bonus per cents apply to total earnings of individuals for the month from which the figures derive and the extra compensation is paid as soon as accounting permits, usually during the following month. Incidentally this plan has been applied to all wage earners as well as to executives.

Example of Plan Based on Shipping Budget.—One company uses the budget for shipping as a base for incentives for groups of salaried employees. All of the clerical employees as well as the key men in the factory participate in the plan. The basis of extra compensation is figured as follows:

The management sets up a certain total sum for monthly shipments which is supposed to be a profitable operation. For shipments made over this fixed sum, a certain per cent of extra compensation is paid and distributed on the basis of each employee's monthly salary. For example, assume that the plant must ship $50,000 in one month before any bonus money can be paid. For every $1,000 shipped over the $50,000, 1% of the monthly salary is paid to each participant. As much as 25% or 30% of the monthly salary may be paid as extra compensation. It has commonly been as high as 10%.

Examples of Plan for Branch Sales Managers.—Branch sales managers may be assigned standards of accomplishment by establishing the volume of sales, the surplus or profit per sale at the branch, the amount collected per open account per period, and the percentage of accounts partially collected during the period. A midwest sewing machine company awards the manager a per cent of salary for each of these accomplishments above standard, but penalizes him at the same rate for falling below the standards. The results are computed every three months. Deficits are carried over against a succeeding bonus period so that the basic salary is not affected. In case of repeated failure, a manager may be transferred to a less responsible post, or he may be dropped. In case of con-

tinued success, there is a definite basis for promotion.[21] An automobile company measures achievement on the following basis:

1. Volume—the proportion of wholesales of the branch to the total of all branches.
2. Competitive standing—the company's share of business in the territory relative to the business in the whole country as disclosed by registrations.
3. Expense—the operating cost of the branch in relation to total sales compared with that of all branches.
4. Progress—an estimate of the degree to which the manager's work has been constructive.

In conclusion we are pleased to quote Howard Coonley, President, The Walworth Co.: "It is my firm belief that to obtain the maximum results in any business undertaking it is necessary to have some form of executive bonus."

References for Additional Cases

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CHAPTER 20

INSTALLATION OF INCENTIVE PLANS

> Belief in the economy of high wages has become prevalent among the abler business executives, much as belief in increasing productivity has become prevalent among the abler trade-union leaders.—WESLEY C. MITCHELL.

First Steps for an Open Shop.—A wage incentive is worse than futile if proper standards of performance are not first developed, and class rates related. All the work of job standardization, including time, and motion study, quality specifications, written standard practice instructions, as well as job evaluation, training, inspecting, and production control, must be completed if best results are to be expected. The employees also need to understand and to welcome the change. This is difficult and requires considerable attention. Printed illustrations of various earnings may be helpful as the money is bound to be one of the first interests of the employee. A conference should be held in which employees are allowed to express their point of view. When numbers are large, department groups or even operation groups may be consulted separately.

First Steps for a Union Shop.—In a union shop all or much of the selling is done by the shop chairman who must be convinced beforehand. Such an official may even want to assume the role of obtaining the incentive plan for his union members. In that case he first shows them how incentives can increase their earnings and promises to persuade the management to make some such change. He then tells the management what is wanted, usually specifying some higher earning which can be made regularly, say 130% of base wages. The management is now able to design a suitable plan, say one which will provide the 130% earning at 100% efficiency. Charts and tables are devised and given the chairman. The latter explains them to his members after which they take an informal ballot for or against acceptance. If the majority vote is against the proposal, management must usually postpone action. If the vote is favorable, representatives for each department or trade may be designated to cooperate with the management in carrying out the installa-

tion. Union people, officials or ordinary members, are not really different from anybody else. They are willing to do their best when they are satisfied that management is doing its best. In general, they only "get tough" if management appears to be getting tough.

Second Steps for All Shops.—In any case a few regular operators who are intelligent and influential should be selected and one by one put on the new plan. These leaders, when convinced of the plan's merits, will bring their friends to desire the same advantages. By this means premature opposition should not develop. If a plan will not work with a few, it will not with many. There should be no great haste in the matter. Failure may forfeit much of the benefit anticipated from expensive job standardization. It should be remembered that new habits of work cannot be acquired without patient assistance. A brief demonstration of new methods is seldom sufficient. Only after many repetitions can old habits be supplanted with the new ones. Production may even decrease until the new automaticity has been firmly acquired. When it is so acquired and the pay envelope shows an increase, then and only then can management feel sure that there will be no reversion to the former low efficiency. Normally there is pride in the more skillful performance. Always there is satisfaction in the higher earning.

Disastrous Effect of Discarding Incentives.—Employees successfully responding to an incentive plan, and, accustomed to high job efficiencies, even for years, will immediately drop back to the usual low day-work efficiencies when for any reason they are deprived of a good incentive. We have known companies to push an incentive plan during a prosperous period and then discard it as soon as orders decreased. They seemed to fear the possibility of a shorter work day more than the loss of morale and the resumption of poor work habits. Union officers sometimes demand suspension of incentives in order to make more man-hours, but efficient workers prefer to take the shorter hours.[1] Management has even more reason to do so. Employees once deprived this way will not have much heart in supporting the next production campaign.

Cost of Installation.—The cost of installation is variable and any data regarding it is of questionable value. It may, however, be of interest to state that one company of consultants charges $500 a week for their complete service. This service includes one full-time man and two supervisions, that is, weekly calls from a field engineer

[1] Recently the withdrawal of incentives at a large airplane factory evoked a threat of striking on the part of union employees.

and monthly calls from a man still higher in the organization. Installation is done completely and a permanent man is broken in. The time taken is never less than six months and is usually from one to two years. Other consultants do no more than to advise and break in resident staff men. A retainer fee is usually charged and further payments are arranged, perhaps contingent on increased profits of the company.

Example of Individual Installation.—L. S. Tyler[2] describes an installation which is applicable to any individual plan: "The way we did was to take an individual operator of whose character and loyalty to the company we were certain, and convince her that this was a scheme worth trying; we were afraid if we tried to explain the thing in detail to the organization or any large section of it, they would simply get lost in the fog, having no experience whatsoever with which to compare what we proposed to do. This one girl undertook to make a trial. Her foreman said publicly he did not believe she would ever make the task, no human being could, and he was sure the thing would go by the board.

"As a matter of fact, she made the task the first time she tried it and was thrilled by the amount of money she received. The result was that after a few weeks when they saw she did not break down under the strain and did not lose any weight (she was quite plump) and everything was going nicely, other operators began to come to us and ask when they were going to be put on the same basis; from that department it spread over to others, and we have been driven to extend the system. If they find there is something inconsistent in the rate, a recommendation for a change is then made. The circumstances are explained and I personally decide whether we will either continue to try the experiment or make the change suggested. The group of operators involved is satisfied before they are asked to perform on a new rate; one of their own number has tried it and the rate is not unreasonable."

Sample Forms for Group Installation.—An eastern oil refining company which has gone to the trouble of adopting several incentive plans to as many different sets of conditions is an excellent company to imitate in the matter of incentives. This particular plan happens to be a group application of an efficiency bonus plan with guaranteed day wage. The scale is slightly below Parkhurst No. 4, but beginning at 66% high task and providing so small a bonus at that point that it can hardly be called a step. The empiric scale ends as in the Emerson plan at the (100, 120) point and gives 1% thereafter as does Emer-

[2] A. M. A. Production Executive Series No. 24.

son. The plan replaced piece work which had been based on unjust rates. The job standardization and rate setting done for the new plan would have removed the trouble under piece rate, but when any plan has been improperly conducted, it is often good psychology to change the whole aspect. The outstanding feature of the new installation is the thorough preparation of plans and instruction sheets. The latter may be noted by the use of the word "proposed" which is dropped as soon as the plan proves successful.

The bonus is generally computed on a time efficiency basis. A factor is given on the Daily Operation Form which, multiplied by the production, gives the standard time in man-minutes for the day. This is divided by the actual time in man-minutes for the day to give the efficiency of the group. On the Standard Bonus Table 70, the amount of bonus paid for the various efficiencies is found. This per cent bonus is added to the men's daily wage. The foreman's bonus is figured on the average efficiency for the pay period of two weeks. The bonus is sometimes figured on a wage efficiency rather than a time efficiency basis. This is due to the character of labor on the location, and is a means of governing the class of labor used on the various operations.

TABLE 70. STANDARD BONUS TABLE

Daily Per Cent Efficiency	Daily Per Cent Bonus	Daily Per Cent Efficiency	Daily Per Cent Bonus	
66	.6	84	5.7	
67	.9	85	6.4	
68	1.1	86	7.2	
69	1.2	87	8.0	
70	1.2	88	8.8	
71	1.2	89	9.7	
72	1.3	90	10.6	
73	1.3	91	11.5	
74	1.4	92	12.4	
75	1.6	93	13.3	
76	1.8	94	14.2	
77	2.1	95	15.2	
78	2.4	96	16.1	
79	2.8	97	17.0	straight line premium
80	3.3	98	18.0	
81	3.8	99	19.0	
82	4.4	100	20.0	
83	5.0			

For daily efficiencies over 100% add 1% premium for each additional per cent of efficiency.
Premium in excess of 100% shall be paid as 100% premium.

Package Department Standard

No. 1 Lubricating Barreling House

Supersedes all previous standards
and supplements

Operation

1. Receiving and light weighing empty packages for filling.
2. Filling all barreled oil and petrolatum at No. 1 Lubricating Barreling House and No. 1 Lubricating Barreling House Pier.
3. Shipping all barreled oil or petrolatum from No. 1 Lubricating Barreling House or Pier to Teams, Trucks or Cars.
4. Reshipping filled or empty barrels and drums, and miscellaneous packages, from other filling locations to cars.
5. Transferring filled or empty packages from No. 1 Lubricating Barreling House to No. 2 Lubricating Barreling House.

Note: In this standard, the term "package" shall be construed to mean wood barrels and kegs, steel barrels or steel drums.

Gang

The General Foreman and Foreman shall determine the size of the gang according to the volume of work scheduled for the day.

Proposed Earnings (At 100% efficiency)

	Old Hourly Piece Rate Earnings	Guaranteed Hourly Earnings	Proposed Hourly Earnings
Foreman	.639	.75	.90
Cooperage Inspector	.643	.56	.672
Weigher	.677	.56	.672
Stenciller	.594	.48	.576
Filler	.564	.48	.576
Platform Laborer	.514	.48	.576

Proposed Costs

* Old cost per barrel (Based on Year)	$ .118545
** Proposed cost per barrel	.0882947
Proposed saving per barrel	$ .0302503

* Sum of the following six unit costs shown on the Three and Six Months Cost Statements of the Manufacturing Statistical Department:

1. Receiving and Inspecting
2. Reshipping
3. Direct Filling
4. Direct Shipping
5. Indirect Filling
6. Indirect Shipping

** Based on an average production per day of 350 barrels.

THE IMPROVEMENTS IN THIS OPERATION ARE:

1. The men will be working on an incentive basis 100% of the time instead of 45.7% as at present.
2. Lower unit cost due to the increased efficiency of the men working 100% of the time on incentive.
3. Lower unit cost due to a more accurate varying of the size of the gang to the production.
4. Better supervision through increased pay for the Foreman.
5. Elimination of one clerk, whose duties will be almost entirely absorbed by the Weigher and the Foreman.

ANNUAL SAVING

90,000 Barrel production	$2,722.00
Services of one clerk	1,260.00
Total annual saving	$3,982.00

PAYMENT AND COMPUTATION

1. The Foreman shall record each day's work for the gang on the Daily Operation Form, made out in quadruplicate, and send all copies to the Superintendent of the Filling and Shipping Department for his approval. The following must be shown:

   (a) Total man-hours spent on each direct labor operation and on indirect labor.
   (b) The production on each operation.
   (c) The actual man-minutes expended for each operation and for indirect labor.
   (d) The total lost time if any, with cause and length of time lost, at the bottom of the sheet.
   (e) Standard man-minutes of each operation and the indirect labor allowance.
   (f) Base wage expended for each operation and for indirect labor.
   (g) The clock card numbers of all men who worked with the gang.
   (h) Efficiency and per cent incentive earned.

2. The efficiency of the gang shall be computed by dividing the standard man-minutes allowed for the day by the actual man-minutes expended that day.
3. The per cent bonus earned shall be that corresponding to the efficiency for the day as shown on Standard Bonus Table.
4. The Superintendent shall forward these reports, after approval, to the Time Department.
5. The Time Department shall check the report, and send one of the corrected copies to each of the following:

   (a) Superintendent of Filling & Shipping Department.
   (b) Foreman.
   (c) Industrial Engineering Department.

   The original copy shall be kept as a record for the payment of bonus.

6. The Foreman shall post a correct record of the bonus earned daily, in a convenient place where the gang shall have access to it.
7. The time cards shall not be coded, but shall be stamped "Bonus" by the Foreman, with the number assigned to the bonus plan.
8. The bonus for all men, except the Foreman, shall be computed on a daily basis.
9. The bonus for the Foreman shall be computed on the basis of the pay period. The efficiency of the gang shall be obtained by dividing the total standard man-minutes by the total actual man-minutes for the pay period. The per cent of bonus corresponding to the efficiency of the gang shall be obtained from the bonus table as described above.

CONDITIONS

1. *The gang will be supplied with:*
   (a) A routine of work for the day.
   (b) All equipment listed under "Detailed Operations."
   (c) Sufficient supplies in a convenient place.
2. In case a number of unsuitable packages are delivered to No. 1 Lubricating Barreling House, the work necessary to repair these shall be done by those responsible for the defects, and the time not charged to the bonus.

DUTIES

The gang shall be required to:

1. Perform tasks in accordance with the Foreman's direction and to his satisfaction.
2. Notify Foreman upon completion of tasks.

The Foreman shall:

1. Place orders in proper file.
2. Make up sample tags and headings on gauge sheets.
3. Report when local orders are filled; make out proper records, and check them on to teams or trucks.
4. Check the shipments going into freight cars and record them on the proper car shipment form.
5. Schedule the incoming empty packages with the orders in such a way that the Stenciller and Filler will not be held up for lack of empty barrels or drums.
6. Avoid having too many empty packages in the Filling Room at one time, in order that the men will have sufficient room in which to work. Stacking empty packages in two tiers shall be avoided as far as possible.
7. Be responsible for all work performed.

EQUIPMENT

1. General equipment shall consist of:
   (a) Inclined skids.
   (b) An economy electric hoist.
   (c) Rags.
   (d) Gasoline.
   (e) One two-wheel hand truck.
   (f) Two scales.

2. Specific equipment as shown under each item of "Detailed Operations."

DETAILED OPERATIONS

Stencilling and Receiving

1. Equipment shall consist of:
   (a) Stencil paper.
   (b) Standard stencils.
   (c) Numbering wheel.
   (d) Ink of necessary colors.
   (e) Stencil brushes.
   (f) Thinner for ink.
   (g) Paints and necessary thinners (for repainting barrels and drums).
   (h) Two stencil-cutting machines.

2. The Foreman will give the Stenciller a list of orders for packages to be filled.
3. If any stencils have to be cut at No. 2 Lubricating Barreling House, the Stenciller will endeavor to get this work done in as few trips as possible. The Foreman will be expected to cooperate as closely as possible with the Stenciller in doing this.
4. When the stencils have been secured, the empty packages will be stencilled in the normal way, arranging the work so that the seals may be stencilled on a full row of packages at one time. The Stenciller shall place the stencilled packages as near the manifolds as possible.
5. Empty packages will be received as the teams arrive and stored in the No. 1 Lubricating Barreling House stencil bay.
6. The Stenciller will have a number of packages stencilled in the evening so the Fillers may start work immediately in the morning.
7. In receiving packages to be filled on the pier, they will be taken directly from the receiving incline, down the platform to the pier, where they will be stencilled.

Filling

1. Equipment shall consist of:
   - (a) Filling spigots and hoses.
   - (b) Clean sample bottles.
   - (c) Sample tags.
   - (d) Bungs.
   - (e) Bung bucket.
   - (f) Bucket of glue.
   - (g) Hammer.
   - (h) Scraper.
   - (i) Wrenches.
   - (j) Pliers.
   - (k) Extra plugs.
   - (l) Assorted gaskets.
   - (m) Naphtha bucket.
   - (n) Steam line for cleaning spigots.
2. The Filler will get the same tags from the Foreman's Office, and find what grades of oil are to be filled.
3. He will open the valves of tanks containing these oils.
4. The Filler will get the empty packages, place in position to be filled, fill to proper ullage, seal properly, and roll away from the manifold to the Weigher.
5. The Filler and Stenciller will arrange the filling so as to have enough spigots running to avoid waiting for barrels to fill.
6. The filling of all lots of similar oils shall be grouped so as to avoid blowing the manifolds clear more often than necessary.
7. The temperature of the oil, if above 115° F., shall be reported to the Foreman, and filling stopped on wood packages, except petrolatum grades. Bright oils shall not be filled into wood packages over 100° F.
8. In filling barrels or drums on the No. 1 Lubricating Barreling House Pier, the Filler will roll the filled packages as far as the door into the No. 1 Lubricating Barreling House, in order that the momentum of the filled package will carry it near to the scale.
9. Five minutes before the end of the day, the Filler will stop filling and close the valves of the tanks, while the Stenciller brands barrels for the next day.

Weighing

1. Equipment will consist of:
    (a) Stencil wheels.
    (b) Stencil brushes.
    (c) Ink for brushes.
    (d) Two adding machines.
    (e) Necessary record sheets.

2. The Weigher will roll all filled packages on to the scale; record gross weight, net weight, kilos, gallons, and number on packages, according to requirements.
3. The Weigher will make the necessary record on gauge sheets or gallonage cards, and roll the finished package on to the platform.
4. While waiting for filled packages, the Weigher will make other necessary records.
5. Whenever possible, the Weigher will assist in platform labor operations.

Shipping

1. Equipment shall consist of:
    (a) Steel plates.
    (b) Blocks of wood.
    (c) Pinch bar for opening car doors.
    (d) Saw and hammer for chocking.
    (e) Tenter-hooking and punching equipment.
2. The platform laborer and cooper will clean out the cars, and carry and saw dunnage wood, until the filled packages arrive in quantity from the filling room. Then the platform laborer will complete this work.

3. *Coopering and Inspecting*
    (a) The Cooperage Inspector will inspect all packages before they are shipped to cars or teams.
    (b) In case a barrel needs coopering, it will be placed to one side and repaired when the platform work is not pressing.
    (c) The Cooper shall assist the platform laborer in shipping packages to teams and cars, etc., in addition to coopering or inspecting.

4. *Rolling to Cars and Stowing*
    (a) The Shipper will take the filled packages from in front of the scale and roll them to the proper car door. When a sufficient

number have been grouped near the car door, one Shipper will enter the car, receive a filled package from another Shipper on the platform, chime it to place, and return for the next package.

(b) If there is only one man doing the shipping, he will roll the package from the scale to the car door; roll it into the car; chime it to place, and return to the scale for another package.

(c) Should the floor of the car be on the same level as the platform, the filled packages shall be rolled, on their sides, from the platform to their place in the car. When a sufficient number have been thus rolled into the car, two men will enter and up-end and place the packages.

(d) Where the car floor and platform are on the same level, an iron plate shall bridge the gap; where the car floor is lower than the platform, the iron plate will rest on the platform and on a block of wood on the car floor.

(e) Drums shall be rolled singly at all times.

5. *Tiering*

(a) The standard gang will consist of two men. One man will carry dunnage wood to the car while the other man arranges it on the first tier of packages. Both men will then roll the tiering machine to the car door, place it in the proper position and connect it with the electric current. They will group as many packages as possible close to the machine.

(b) One man will remain in the car, receiving and rolling the packages to place. The other man will roll the packages on to the tiering machine and operate it.

(c) When the packages within a half car-length of the machine have been stowed, both men will leave the car and roll more packages nearer the machine. The operation of tiering and stowing will then be resumed.

6. *Chocking and Sealing Cars*

(a) The gang will consist of one man. Shoring will be cut to the proper length, securely nailed in place, according to the method of shoring now in use, and required by railroad regulations. When properly shored and passed by the Foreman, the car doors shall be closed and sealed.

7. *Shipping to Teams and Trucks*

(a) The Shipper will roll the packages from the scale to the west end of the platform and arrange them for the Driver to roll them on to the truck.

8. *Tenter-hooking and Punching Wood Barrels*

   (a) The Cooperage Inspector or another member of the gang will tenter-hook and punch all wood barrels filled at No. 1 Lubricating Barreling House and Pier, except those shipped to the Philadelphia Wharf, and those for domestic shipment not requiring tenter-hooking and punching.

9. *Transferring Filled Packages from No. 1 Lubricating Barreling House to No. 2 Lubricating Barreling House, or Vice Versa*

   (a) The barrels for No. 2 Building will be rolled to the west end of the platform.
   (b) One of the laborers from No. 1 Building shall place two "Stop—Men at Work" signs on the railroad track.
   (c) Two laborers from each building will place the trestle across the railway tracks from No. 1 Platform to the Grease Plant Platform or to a car at that location.
   (d) They will deliver the packages across the trestle.
   (e) Two laborers from each building will remove the trestle.
   (f) The Shippers from No. 1 Building will stow the barrels received from No. 2 Building in the normal way.

Miscellaneous Operations

1. All miscellaneous operations not listed as direct labor operations shall be charged as indirect on the Daily Operation Form. Jobs shall be coded on the Daily Operation Form according to the Filling & Shipping Code.

2. Miscellaneous operations shall include:

   (a) Repainting empty or filled packages.
   (b) Unloading empty packages from cars.
   (c) Loading tanks, pumps, etc., into cars.
   (d) Receiving, weighing and dumping slop oil.
   (e) All other items not specifically stated, except those covered by General Standard.

Standard Times and Rates of Production

	Standard Production Per Man-Hour	Standard Man-Minute Time Per Unit
1. Receive wood barrels and drums..............	160	.3753
2. Receive and light weigh steel barrels..........	90	.6652
3. Stencil "Socony" brands.....................	44	1.3677
4. Stencil "Atlantic" brands....................	78	.7671
5. Filling wood barrels—main manifolds.........	58	1.0319
6. Filling wood barrels—Pier & Man.............	50	1.1903
7. Fill steel barrels and drums..................	38	1.5778
8. Fill Petrolatum drums—15" opening..........	13	4.4693
9. Weigh all barrels and drums.................	70	.8597
10. Additional weighing allowance (set of figures)...		.2213
11. Ship to cars or teams.......................	32	1.8858
12. Cooper or inspect all barrels and drums........	86	.6966
13. Transfer from #1 to #2, or vice versa..........	13	4.6895

Standard Gang Production and Miscellaneous Allowance

The standard time for receiving, stencilling, filling, weighing, coopering or inspecting, and shipping the average package, is 5.921743 man-minutes. From this basis a scale of gang production and miscellaneous labor allowance has been built up, Table 71.

Table 71. Standard Allowances for Direct Labor

* Number in Gang	Man-Hours	Man-Minutes	Production	Miscellaneous Labor Allowance
1	9	540	91	
2	17	1020	172	1 hour
3	26	1560	263	
4	34	2040	345	2 hours
5	43	2580	436	
6	51.5	3090	522	2.5 hours
7	60.5	3630	613	
8	69	4140	699	3 hours
9	78	4680	790	
10	86.5	5190	876	3.5 hours
11	95.5	5730	968	

* Not including the Foreman.

From the above range of Miscellaneous Labor Allowances, the following scale of Daily Indirect Labor Allowances has been drawn up.

The Indirect Labor Allowance shall be composed of the Foreman's full time, plus the proper amount of Miscellaneous Labor, as shown by Table 72.

Table 72. Standard Allowances for Indirect Labor

Gang	8-hour day	4-hour day	Overtime ½ hr.
1 man			
2–3 men	60 m.m.	30 m.m.	4 m.m.
4–5 men	120 m.m.	60 m.m.	7 m.m.
6–7 men	150 m.m.	75 m.m.	9 m.m.
8–9 men	180 m.m.	90 m.m.	10 m.m.

Installing an Incentive for a Stores Group.—A company making vacuum cleaners recently installed a bonus plan for the factory stores department consisting originally of 29 employees. Three "control values" were set up as follows:

A. Value of material received and material issued per stores labor-hour (weight 5).

B. Value of units assembled and of material issued to Service department per stores labor-hour (weight 3).

C. Direct labor-hours in factory departments plus Maintenance department labor-hours per Stores labor-hour (weight 4).

Data on the above were recorded for 24 months, averaged and set up for standards against which future performances could be measured. Two meetings were held between management and employees concerned to explain and discuss the proposed plan. The employees then appointed a committee of three of their members to assist the management in making changes as suggested. To enlist cooperation during the trial period the management guaranteed a minimum of 6% bonus which terminated as such at the end of two months. It also agreed to transfer any excess labor to other departments. Foremen were put on a new bonus, made dependent on results of the group, and the bonuses of all were posted at the end of each month. In three months the force had been reduced 20% and by the end of the first year the remaining employees were averaging 17.7% bonus. After three years (1940) the cost of stores labor per weighted unit had decreased 33%.[3]

Retrospect of the Whole Remuneration Question.—In drawing this book to a close, it seems appropriate to touch briefly upon the connection which remuneration has in general with prosperity. Long ago, the German writer, Brentano, pointed out that, "Die Lohnfrage ist eine Kulturfrage." More recently, Professor Munro of Harvard has reiterated the principle in terms of a democracy. "To the great majority of men, the immediate measure of civilization is the purchasing power of a day's labor." And finally, ex-President Coolidge voiced an opinion which recognizes the principle in results. "With general prosperity, with high wages, with reasonable hours of labor, have come both the means and the time to cultivate the artistic spirit." Of course, the finer things do not always keep step with material well-being but they catch up eventually and in modern mass prosperity they have been brought within the reach of more people than ever before, anywhere. In short, the high efficiencies that have usually come through incentive plans constitute one of the sources from which our wealth and well-being are created.

"The *wage incentive* is recognized as one of the most potent and dependable stimulants to increased production of wealth."[4]

[3] A. M. A. Production Series, No. 130.
[4] Merritt Lum, *Mechanical Engineering*, Vol. 60, No. 4.

APPENDIX A

HOW TO USE PREFERRED NUMBERS

Preferred Numbers[1] for Wage Scales.—Preferred numbers, or a series of values developed according to geometrical law, have long been used for the determination of machine tool speeds and are now being used for many other purposes in place of accidental progressions. The reasons for using them are:

To establish a minimum of standard sizes and ratings.
To eliminate odd and special sizes and ratings.
To simplify and cheapen production.
To simplify calculations.
To provide easy methods to half or double sizes or ratings in a preferred series.
To provide easy methods to reconcile and determine conflicts in practice because of adoption of a law.
To produce products so designed that even if made in different industries they will fit together when assembled.

According to Weber's law of discrimination, when sensations or responses are in arithmetical relationship, the corresponding stimuli form a geometric series. Preferred numbers are, therefore, particularly suited for the reward of human progress. The trouble is that in gaining such a progressing series, there may be a loss of even numbers. It is, therefore, practical to modify them or, in other words, compromise. Many factors are already in use and their series are available in print.[2]

Formula for Promotion Series.—For a true preferred number series, the factor by which each item is multiplied in succession should be derived as follows:

Let f = factor
" Z = last item in series
" A = first item in series
" n = number of steps (number of items minus one)

1 Carl G. Barth, A. S. M. E., Vol. 44. *Management and Administration,* Vol. IX, No. 12. Mr. Barth used them in 1904 for machine-hour rates.

2 American Engineering Standards Committee Report, June, 1927. L. P. Alford, *Laws of Management Applied to Manufacturing.* A. M. A. Institute of Management Series No. 14.

Then for n series, $f = \sqrt[n]{\frac{Z}{A}}$

Series would be $A, fA, f^2A, f^3A, \ldots\ldots\ldots\ldots f^nA$, or Z

With this formula, any desired number of steps may be set up between any two fixed values and the resulting series will be truly geometric. Without this formula, either one end or the other of a standard series must be sacrificed to apply it to the fixed values and only part of the geometric curve is represented.

APPENDIX B

DESIGN OF ACCELERATING PREMIUM PLANS

Procedure.—The development of the formulas will first be made with the simple nomenclature of ordinary mathematics, into which substitution of the standard nomenclature of wage incentives may be made. The order of procedure in each case will be the determination of the parametric constants of the curves, the solution of the equations of the curves in order to determine the coordinates thereof, and the formulation of the vertical intercept and slope of the tangent line at any point so that the tangents can be equated and used as the analyzers for their respective curves. It will be found that the complete formulation of these "analyzers" dispenses with the solution of the curves proper so that the analyzers can be compared directly with any other form of wage plan expressed in a linear equation. Their solution as part of the general solution presents, however, certain arithmetic conveniences.

Nomenclature.—The preliminary nomenclature for the abstract development of the formulas will be as follows;

x and y = Coordinates of curve.

a and b = Temporary parametric constants of abstract curves which will be abandoned as soon as determined in the assumed constants for the placed curve.

b = Except for next above, will denote the vertical intercept of the tangent "analyzer" on the vertical axis.

C_t = Minimum wage paid for a given period.

B = Arbitrary intercept of curve on vertical axis representing minimum wage as a ratio of unity or of standard day wages.

W = Ordinate through high task point representing the ratio of high task wages to standard wages at a point where production as a ratio of standard hours to actual hours has a ratio of unity.

m = The slope of the tangent "analyzer" against horizontal axis.

Development of Hyperbolic Formulas.—In Figure 93,

$$\text{slope of tangent } TPT' = TQ/PQ = m = \frac{dy}{dx}$$

$$\text{intercept } OT = QO - QT = y - mx$$

where $QP = x$, $QO = y$, and $AO = B$.

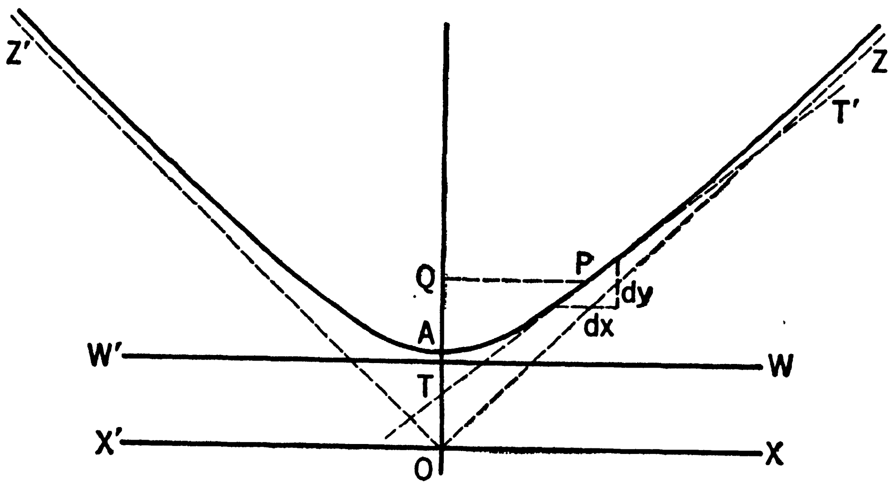

Figure 93. The Conjugate Hyperbola

The standard analytic equation of the conjugate hyperbola is:

$$\frac{x^2}{a^2} - \frac{y^2}{b^2} = -1 \qquad *(1)$$

which becomes $\quad b^2 x^2 - a^2 y^2 = -a^2 b^2 \qquad (5)$

and by substitution $a^2 (y^2 - b^2) = b^2 x^2$

whence $$a^2 = \frac{b^2 x^2}{y^2 - b^2} \qquad (6)$$

Now by hypothesis, the curve is to be passed through two points such that (a) $x = 0$ when $y = B$, (b) $x = 1$ when $y = W$ whence substitution of (a) in (5) gives:

$$b^2 0^2 - a^2 B^2 = -a^2 b^2, \text{ whence } b = B \qquad (7)$$

while substitution of (7) and (b) in (6) gives

$$a^2 = \frac{B^2}{W^2 - B^2} \qquad (8)$$

* For other equations see Chapter 15.

Reduction of (5) gives:

$$a^2 y^2 = b^2 (a^2 + x^2) \tag{9}$$

in which (7) and (8) are to be substituted to give:

$$y^2 = \frac{B^2 x^2}{a^2} + B^2 \text{ and } y^2 = B^2 \left(1 + \frac{x^2}{\dfrac{B^2}{W^2 - B^2}}\right) \tag{10}$$

$$\text{whence } y^2 = B^2 \left[\frac{B^2 + (W^2 - B^2)\, x^2}{B^2}\right] \tag{11}$$

$$\text{whence } y = \sqrt{B^2 + W^2 x^2 - B^2 x^2} \tag{12}$$

and the curve can pass through two arbitrary points, A and P, Figure 93. Now if x_t and y_t = coordinates at point of tangency a tangent can be passed through the point P, whose equation becomes:

$$(y - y_t) = \frac{dy_t}{dx_t}(x - x_t) \tag{13}$$

Since equation (12) expands to

$$y^2 = B^2 + W^2 x^2 - B^2 x^2 \tag{12a}$$

its derivative becomes $2\, ydy = 2\, W^2 xdx - 2\, B^2 xdx$ whence by simplification,

$$\frac{dy_t}{dx_t} = \frac{(W^2 - B^2)\, x_t}{y_t} \tag{14}$$

and substituting this in (13),

$$(y - y_t) = (W^2 - B^2) \frac{x_t}{y_t}(x - x_t) \tag{15}$$

expanding and transposing,

$$yy_t = y_t^2 + (W^2 - B^2)\, xx_t - (W^2 - B^2)\, x_t^2 \tag{16}$$

but from (12a) above,

$$y_t^2 - B^2 = (W^2 - B^2)\, x_t^2 \tag{17}$$

whence,

$$\frac{y_t^2 - B^2}{x_t} = (W^2 - B^2)\, x_t \tag{18}$$

and by substitution in (16),

$$yy_t = y_t^2 + \frac{y_t^2 - B^2}{x_t} x - (y_t^2 - B^2) \tag{19}$$

which reduces to,

$$yy_t = \frac{(y_t^2 - B^2)}{x_t} x + B^2 \tag{20}$$

and further reduction gives

$$y = \frac{y_t^2 - B^2}{x_t\, y_t} x + \frac{B^2}{y_t} \tag{21}$$

which is the *equation of the tangent through the point* (x_t, y_t) in the conventional form

$$y = mx + b \tag{22}$$

Since the two expressions can be equated so that,

$$mx + b = y = \frac{y_t^2 - B^2}{x_t\, y_t} x + \frac{B^2}{y_t} \tag{23}$$

then by the principle that the coefficients of terms of like powers must be equal to each other

$$\text{slope } m = \frac{y_t^2 - B^2}{x_t\, y_t} \tag{24}$$

$$\text{and intercept } b = \frac{B^2}{y_t} \tag{25}$$

and by substitution in equation (12a),

$$\text{slope } m = \frac{(W^2 - B^2)\, x_t}{\sqrt{B^2 + (W^2 - B^2)\, x_t^2}} \tag{26}$$

$$\text{and intercept } b = \frac{B^2}{\sqrt{B^2 + (W^2 - B^2)\, x_t^2}} \tag{27}$$

The solution for the slope of the analyzer can be simplified by recourse to the general formula for the slope of a straight line,

$$m = \frac{y_2 - y_1}{x_2 - x_1}$$

If $x_1 = 0$ when $y_1 = b$, and $x_2 = x$ when $y_2 = y$, in terms of the curve coordinates, then

$$m = \frac{y - b}{x} \tag{22}$$

Occasionally it becomes necessary to solve for the abscissa when the ordinate is given. Thus it may be desired to find the abscissas corresponding to the point where the earning curve crosses through standard time wage line, or in the present terminology when ($y = 1$). Resort is made to the general equation of the curve where

$$y^2 = B^2 + (W^2 - B^2)\,x^2 \tag{11}$$

transposing $$(W^2 - B^2)\,x^2 = y^2 - B^2 \tag{11a}$$

whence $$x^2 = \frac{y^2 - B^2}{W^2 - B^2} \tag{11b}$$

which is a reversible solution and readily fits into the tabular solution for y as will be demonstrated later. The equation, however, reduces by factoring to

$$x^2 = \frac{y - B}{W - B} \cdot \frac{y + B}{W + B}$$

which will allow comparison with the parabolic curve developed later.

A Graphic Solution.—The equation of the curve,

$$y = \sqrt{W^2\,x^2 + B^2 - B^2\,x^2} \tag{11}$$

and the equations for the intercept and slope of the tangent to the curve,

$$b_t = \frac{B^2}{y} \text{ and } m = \frac{y - b}{x}$$

lend themselves readily to a simple graphic solution (Figure 94). Let the triangles ADE = a right triangle at D, ABC = a right triangle at B, ADC = a right triangle at D, AEF = a right triangle at E, GAH = a right triangle at A. Then $(AB)^2 + (BC)^2 = (AC)^2$ and $(AC)^2 - (CD)^2 = (AD)^2$,

whence $$(AB)^2 + (BC)^2 - (CD)^2 = (AD)^2$$

and $$AD \cdot DF = (ED)^2 \text{ if } DF = DG$$

or $$DF = \frac{(ED)^2}{AD} \text{ and } AG = AD - DF$$

Now if $AH = x, AB = Wx$, then $AG/AH =$ tan angle $AHG = m$, $BC = B$, $CD = bx$, $AD = y$, $DE = b$, $DF = b_t$, $AG/AH = m$,

then $$AD = y = \sqrt{W^2x^2 + b^2 - b^2x^2}$$

and $$DF = b_t = \frac{b^2}{y} \text{ by proportion} \tag{25}$$

The construction of the graphic solution is easily done as follows:

1. Lay off the distance AB equal to Wx.
2. At B, erect a perpendicular and lay off the distance BC equal to b.
3. Connect the points A and C by a straight line which is to be bisected at O.

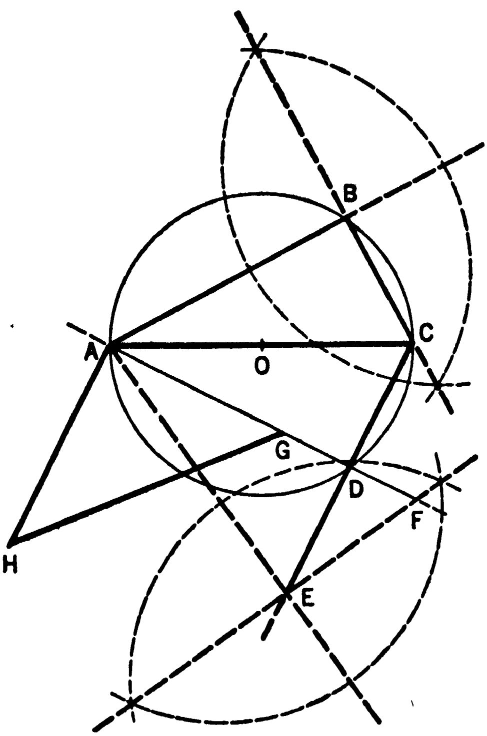

Figure 94. Graphic Computation of Hyperbola Formula

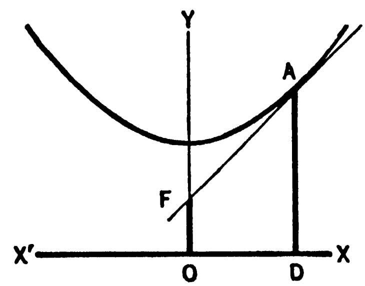

Figure 95. Relocating the Conjugate Hyperbola

4. With O as a center describe a circle through the points $ABCD$.
5. With C as a center strike a radius through D so that CD is equal to bx.

6. Connect the points C and D by a straight line extending to a point E beyond.
7. Connect the points A and D by a straight line extending to a point F beyond.
8. On the line CDE lay off the distance so that DE is equal to b.
9. Connect the points A and E by a straight line and erect a perpendicular thereto at E, to intersect the line ADF at F.

Then, referring to Figure 95, if an ordinate AD is erected to the curve at a distance $x = OD$ and a tangent drawn through the point A, the ordinate AD is determined by measuring AD in Figure 94 and the intercept FO in Figure 95 by measuring the length DF in Figure 94.

The Hyperbolic Functions Method.—The computation for the elements of the hyperbolic rule for wage payments will be made first by the use of hyperbolic functions and secondly by the algebraic method. The application of hyperbolic functions has been utilized primarily to illustrate the method while the algebraic routine is added to show that the results are identical by the two methods. The shorter and simpler method, viz., the use of "hyperbolic functions," is available for the formulation of the desired elements of the hyperbolic curve and its analyzer. First, however, the several expressions of the algebraic solution must be transformed somewhat. Thus the equation of the ordinate

$$y^2 = B^2 + (W^2 - B^2)\, x^2 \tag{11}$$

becomes

$$y^2 = B^2 \left[1 + \left(\frac{W^2 - B^2}{B}\right) x^2\right] \tag{10}$$

and the equation of the intercept $b = \dfrac{B^2}{y}$ (25)

becomes

$$b = \frac{B^2}{B\sqrt{1 + \left(\frac{W^2 - B^2}{B^2}\right) x^2}} = \frac{B}{\sqrt{1 + \left(\frac{W^2 - B^2}{B^2}\right) x^2}} \tag{27}$$

Now since $\cosh^2 u = 1 + \sinh^2 u$

we may write $\sinh^2 u = \left(\dfrac{W^2 - B^2}{B^2}\right) x^2$ (28)

whence $$y^2 = B^2(1 + \sinh^2 u) = B^2 \cosh^2 u \tag{29}$$

and $$y = B \cosh u \tag{30}$$

substituting in $$b = \frac{B^2}{y} = \frac{B^2}{B \cosh u} \tag{31}$$

there results $$b = \frac{B}{\cosh u} \tag{32}$$

and from (22), $$m = \frac{y - b}{x} = \frac{B \cosh u - \dfrac{B}{\cosh u}}{x} \tag{33}$$

reduction gives $$m = \frac{B(\cosh^2 u - 1)}{x \cosh u} = \frac{B \sinh^2 u}{x \cosh u} \tag{34}$$

The solutions for the required functions of the hyperbolic curve can now be assembled and written

$$y = \sqrt{B^2 + (W^2 - B^2)\,x^2} \tag{11}$$

$$m = \frac{y^2 - B^2}{xy} \tag{24}$$

$$m = \frac{y - b}{x} \tag{22}$$

$$b = \frac{B^2}{y} \tag{25}$$

$$x^2 = \frac{y^2 - B^2}{W^2 - B^2} \tag{11b}$$

where the algebraic solution is to be used. If, however, the solutions are to be made by means of hyperbolic functions then the formulation becomes:

$$\sinh u = x\sqrt{\frac{W^2 - B^2}{B^2}} \tag{28}$$

$$y = B \cosh u \tag{30}$$

$$b = \frac{B}{\cosh u} \tag{31}$$

TABLE 73. HYPERBOLIC COMPUTATIONS BY FUNCTIONS METHOD*

Column	Manipulate Columns as Indicated	Values Represented in Columns	Description of Manipulation of Columnar Values—down with light face for y and **up with bold face for x.**	Reverse Solution for x
A	Assumed argument	x	Assume all necessary or desired values of "x" and enter in orderly array in this column. **When solving for x divide sinh u of column C by the value of the constant in column B and enter here.**	C ÷ B
B	Computed constant	$k = \sqrt{\frac{W^2 - B^2}{W^2}}$	This constant is computed by manipulating the parametric constants of the curve as indicated or by $k = \sqrt{\left(\frac{W + B}{W}\right)\left(\frac{W - B}{W}\right)}$ for easier computation.	Computed constant
C	A × B	sinh $u = kx$	Multiply the values of columns A and B to obtain the values of sinh u which are to be used as the argument for cosh u. **Read values of sinh u corresponding to cosh u (of column D) from tables and enter here.**	Read from tables opposite cosh u as argument
D	Read from tables opposite sinh u as argument	cosh u	Read values of cosh u from tables corresponding to sinh u (of column C as argument) and enter here. **Divide the values of column F by those of column E when solv'ng for x and enter here.**	F ÷ E
E	Given parametric constant of curve	B	The intercept of the hyperbolic curve used. **When solving for y when b is given squares this constant to divide the square by b. Enter in F.**	Given parametric constant of curve
F	E × D	$y = B \cosh u$	Multiply the values of columns D and E for y and enter here. **Enter assumed values of y here or compute from relation $y = B^2 + b$.**	Assume ordinate or compute from data
G	E ÷ D	$b = \frac{B}{\cosh u}$	Divide the values entered in column E by the determined values in column D and enter here.	**Proceed upward as indicated to solve for x when y is given.**
H	F − G	$y - b$	Deduct the values of column G from those of column F and enter here for the intermediate step in determining the slope of the analyzer.	
I	H ÷ A	$m = \frac{y - b}{x}$	Divide the values in column H by those in column A to obtain the slope of the analyzers for any point and enter here.	

* An additional column J may be used to determine an analyzer value.

$$m = \frac{B \sinh^2 u}{x \cosh u} = b \cdot \frac{\sinh^2 u}{x} \tag{34}$$

which present a simple solution except for m and that is best determined by the algebraic method immediately preceding.

The computations when utilizing hyperbolic functions arrange themselves in columnar form as in Table 73. First a constant must be computed from the parametric constants of the equation, then this constant multiplied by the successional values of x to give the successional values of "sinh u" which are used as the argument in a parallel table of hyperbolic functions to determine "cosh u." y and b are then determined by simple multiplication and division and the values entered in the proper column. Thereafter proceed algebraically.

The Algebraic Method.—Computations are best made in a systematic manner, and where such computations can be resolved into single steps involving the manipulation of but two quantities at a time, the columnar method of accounting (sometimes called the statistical method) presents the most feasible procedure. In general the abscissa (x) will be taken as the argument, and the other elements computed for each changing value of x. However, since the point where the ordinate becomes unity is also required, the reversed computation for x in terms of y will be indicated for the tabular arrangement. Taking the equation for the ordinate of the hyperbolic curve,

$$y^2 = (W^2 - B^2)\, x^2 + B^2 \tag{11}$$

Since $(W^2 - B^2)$ and B^2 are constants, they need be computed but once. Thus having B given it is multiplied by itself outside the columnar arrangement, and the value of B^2 merely entered in a column provided for it. Likewise, $(W^2 - B^2)$ breaks up into factors $(W - B)\ (W + B)$ which can also be computed almost by inspection outside the columnar arrangement and the final value entered in a column provided for the purpose. Since x is the argument for the computations, column A, Table 74, must be provided for it. A second column must then be provided for the first manipulation on the argument (x), to wit, its squaring. The next manipulation is to multiply the square of the argument by the constant $(W^2 - B^2)$ already assigned a column, and a fourth column is required for the product. The constant B^2 must now be added and the constant and the resulting sum each require a fifth and sixth column respectively. The cumulative computation has now reached the stage where

$$(W^2 - B^2)\, x^2 + B^2 = y^2 \tag{11}$$

The square root is now extracted from both sides of this expression with the result that

$$y = \sqrt{(W^2 - B^2)\,x^2 + B^2} \tag{11}$$

and a seventh column must be provided for the answer which is the numerical value of the ordinate. Since the intercept of the tangent at the point (x, y) is determined by

$$b = \frac{B^2}{y} \tag{21}$$

for which quantities, on the right-hand side, respective columns of computed values already exist, the indicated division is made and an eighth column provided in which the quotients are entered as the arithmetic value of the "intercept." The slope of the tangent,

$$m = \frac{y - b}{x} \tag{22}$$

is made up of two indicated operations, the difference between the ordinate and the intercept, for which a ninth column must be provided, and the division of this difference by the argument, already assigned the first column, requires a tenth column for the entry of the quotient. This indicated tabular computation furnishes all that is necessary for the determination of the arithmetic values of the three desired elements. There yet remains the determination of the abscissa when the ordinate is given. The computations are summarized in Table 74. When the ordinate is given, a reversal of the columnar computation is required to compute the corresponding abscissa. Thus when a definitive value is assigned to y, this value is entered in the column assigned to y. It is then squared and the result entered in column F, the y^2 column. Next the value B^2 in column E is deducted from the value in column F and the difference entered in column D. This value is then divided by $W^2 - B^2$ in column C and the quotient entered in column B to give the value of x^2. The square root is next extracted and the final solution for x entered in column A.

TABLE 74. HYPERBOLIC COMPUTATIONS BY ALGEBRAIC METHOD

Column	Manipulate Columns as Indicated	Values Represented in Columns	Description of Manipulation of Columnar Values—down with light face for y and **up with bold face for x.**	Reverse Solution for x
A	Assumed Argument	x	Assume all desired or necessary values of x and enter in this column in orderly array. **Enter the extracted roots of column B.**	$\sqrt{B}$
B	A^2	x^2	Square all values in column A and enter here. **Divide values of column D by those of C and enter here.**	$D \div C$
C	Computed constant	$(W^2 - B^2)$	The constant is computed from the parametric constants of the equation either as indicated or by the factors $(W + B) \cdot (W - B)$ and entered here.	Computed constant
D	$B \times C$	$(W^2 - B^2)x^2$	Multiply values of column B by column C and enter here. **Subtract the values of column E from those of column F and enter here.**	$F - E$
E	Computed constant	B^2	The vertical intercept of the curve is to be squared, either by multiplying by itself or taken from tables and the result entered here.	Computed constant
F	$D + E$	$(W^2 - B^2)x^2 + B^2$ or (y^2)	The values of columns D and E are to be added together and entered here. **The values in column G are to be squared and entered here.**	G^2
G	$\sqrt{F}$	y	Extract the square root of the values in column F and enter here. **Enter assumed values of y here. When intercept b is given divide values in column E by those in column H to obtain y.**	Assume ordinate as argument
H	$E \div G$	$b = \dfrac{B^2}{y}$	Divide values in column E by the determined values of column G and enter here for analyzer intercept on vertical axis.	**Proceed upward as indicated to solve for x when y is given.**
I	$G - H$	$y - b$	Deduct values in column H from those in column G for the intermediate step in determining the slope of the analyzer.	
J	$I \div A$	$m = \dfrac{y - b}{x}$	Divide the values in column I by those in column A to obtain the slopes of the analyzer and enter them here.	

Translation Into Standard Incentive Symbols.—Substitution of standard incentive symbols in the developed formulas gives the following development for the hyperbola type of curve. Starting with equation (12),

$$y = \sqrt{B^2 + (W^2 - B^2)\,x^2} \text{ makes } \frac{E}{H_a\,R_h} = \sqrt{B^2 + (W^2 - B^2)\left(\frac{H_s}{H_a}\right)^2}$$

$$\text{equation (25), } b = \frac{B^2}{y} = \frac{B^2}{\dfrac{E}{H_a\,R_h}} = \sqrt{B^2 + (W^2 - B^2)\left(\frac{H_s}{H_a}\right)^2}$$

$$\text{equation (22), } \quad m = \frac{y - b}{x} = \frac{\dfrac{E}{H_a\,R_h} - \dfrac{B^2}{\dfrac{E}{H_a\,R_h}}}{\dfrac{H_s}{H_a}}$$

Simplification of these expressions lead to the following:

$$\frac{E}{H_a\,R_h} = \sqrt{\frac{B^2\,H_a^2 + (W^2 - B^2)\,H_s^2}{H_a^2}} \tag{35}$$

whence

$$E = R_h\sqrt{B^2\,H_a^2 + (W^2 - B^2)\,H_s^2} \tag{36}$$

as the *basic earnings* equation *in terms of performance.*

Since

$$b = \frac{B^2\,H_a\,R_h}{E} \tag{25a}$$

substitution gives

$$b = \frac{B^2\,H_a}{\sqrt{B^2\,H_a^2 + (W^2 - B^2)\,H_s^2}} \tag{37}$$

The first simplification of m gives:

$$m = \frac{\left[\dfrac{E}{H_a\,R_h} - \dfrac{B^2\,(H_a\,R_h)}{E}\right] H_a}{H_s} \tag{38}$$

This in turn reduces to,

$$m = \frac{[E^2 - B^2\,(H_a\,R_h)^2]\,H_a}{E\,H_a\,R_h\,H_s} \tag{39}$$

whence

$$m = \frac{E^2 - B^2\,(H_a\,R_h)^2}{E\,R_h\,H_s} \tag{40}$$

Substituting the value of E there is obtained:

$$m = \frac{R_h^2 [B^2 H_a^2 + (W^2 - B^2) H_s^2] - R_h^2 B^2 H_a^2}{R_h^2 H_s \sqrt{B^2 H_a^2 + (W^2 - B^2) H_s^2}} \tag{41}$$

which on simplification gives,

$$m = \frac{(W^2 - B^2) H_s}{\sqrt{B^2 H_a^2 + (W^2 - B^2) H_s^2}} \tag{42}$$

as the second of the two values which determine the value of the analyzer for any desired value of H_s/H_a. Since $y = mx + b$ for the analyzer, the substitution of the incentive symbology for x and y gives,

$$\frac{E}{H_a R_h} = m \frac{H_s}{H_a} + b \tag{22a}$$

whence

$$E = m H_s R_h + b H_a R_h \tag{22b}$$

and further substitution for b and m gives,

$$E = \frac{[(W^2 - B^2) H_s^2 + B^2 H_a^2] R_h}{\sqrt{B^2 H_a^2 + (W^2 - B^2) H_s^2}}$$

$$= R_h \sqrt{B^2 H_a^2 + (W^2 - B^2) H_s^2} \tag{36}$$

On the other hand, if it is desired to determine what production must be achieved for the receipt of standard wages, substitution is made in the formula,

$$\frac{H_s^2}{H_a^2} = x^2 = \frac{y^2 - B^2}{W^2 - B^2} = \frac{\frac{E^2}{H_a^2 R_h^2} - B^2}{W^2 - B^2} \tag{11b}$$

which reduces to

$$\frac{H_s^2}{H_a^2} = \frac{E^2 - B^2 (H_a^2 R_h^2)}{H_a^2 R_h^2 (W^2 - B^2)} \tag{44}$$

whence

$$H_s = \sqrt{\frac{E^2 - B^2 (H_a R_h)^2}{R_h^2 (W^2 - B^2)}} \tag{45}$$

However, when the use of hyperbolic functions is utilized the substitution becomes sinh $u = x\,K$, where

$$K = \sqrt{\frac{W^2 - B^2}{B^2}} \qquad \text{See (28).} \tag{46}$$

whence
$$\sinh u = H_s \sqrt{\frac{W^2 - B^2}{H_a^2\, B^2}} \tag{47}$$

since
$$\cosh^2 u = 1 + \sinh^2 u$$

$$\cosh^2 u = \frac{B^2 H_a^2 + (W^2 - B^2)\, H_s^2}{H_a^2\, B^2} \tag{48}$$

$$\cosh u = \frac{1}{H_a^2\, B} \sqrt{B^2\, H_a^2 + (W^2 - B^2)\, H_s^2} \tag{49}$$

and since
$$y = \frac{E}{H_a\, R_h} = B \cosh u \tag{30}$$

$$E = R_h \sqrt{B^2\, H_a^2 + (W^2 - B^2)\, H_s^2} \tag{36}$$

Four Hyperbolic Plans.—We may now set up standard tables and charts for as many plans as we choose. It will suffice our purpose here to design four such plans to meet four requirements as to minimum wage, that is, where $B = .40$, $B = .60$, $B = .80$, and $B = 1.00$. If the base wage were \$1.00 per hour these plans would provide starting points at \$.40, \$.60, \$.80, and \$1.00 per hour respectively, with $W = 1.20$ in all of them. Tables 75 to 78 and Figures 96 to 103 give the earning curves (100, 120), tangents, and high piece rate together with analyzer curves for the slopes and intercepts of each earning curve.

TABLE 75. COMPUTATIONS FOR HYPERBOLIC EARNINGS CURVE

Where $W = 1.20$ $B = .40$ $(W^2 - B^2) = (1.2 + .4)(1.2 - .4) = 1.28$ $B^2 = .16$

A	B	C	D	E	F	G	H	I	J
Assumed Argument	A^2	Computed Constant	B × C	Computed Constant	D + E	$\sqrt{F}$	E ÷ G	G − H	I ÷ A
x	x^2	$(W^2 - B^2)$	$(W^2 - B^2)x^2$	B^2	$(W^2-B^2)x^2+B^2$	y	$b_t = \frac{B^2}{y}$	$\frac{y^2 - B^2}{y}$	$m_t = \frac{(W^2-B^2)x^2}{xy}$
.0	.0	1.28	.0000	.16	.1600	.4000	.4000	.0000	.0000
.1	.01	1.28	.0128	.16	.1728	.4157	.3849	.0308	.3080
.2	.04	1.28	.0512	.16	.2112	.4596	.3481	.1117	.5585
.3	.09	1.28	.1152	.16	.2752	.5246	.3050	.2196	.7320
.4	.16	1.28	.2048	.16	.3648	.6040	.2649	.3391	.8478
.5	.25	1.28	.3200	.16	.4800	.6928	.2309	.4619	.9238
.6	.36	1.28	.4608	.16	.6208	.7879	.2031	.5849	.9748
.7	.49	1.28	.6272	.16	.7872	.8872	.1803	.7069	1.0099
.8	.64	1.28	.8192	.16	.9792	.9895	.1617	.8278	1.0348
.81	.65 +	1.28	.8400	.16	1.0000	1.0000	.1600	.8400	1.0370
.9	.81	1.28	1.0368	.16	1.1968	1.0951	.1461	.9490	1.0544
1.0	1.00	1.28	1.2800	.16	1.4400	1.2000	.1333	1.0667	1.0667
1.1	1.21	1.28	1.5488	.16	1.7088	1.3072	.1224	1.1848	1.0771
1.2	1.44	1.28	1.8432	.16	2.0032	1.4153	.1131	1.3022	1.0852
1.3	1.69	1.28	2.1632	.16	2.3232	1.5242	.1050	1.4192	1.0917
1.4	1.96	1.28	2.5088	.16	2.6688	1.6346	.0979	1.5367	1.0976
1.5	2.25	1.28	2.8800	.16	3.0400	1.7436	.0918	1.6518	1.1012

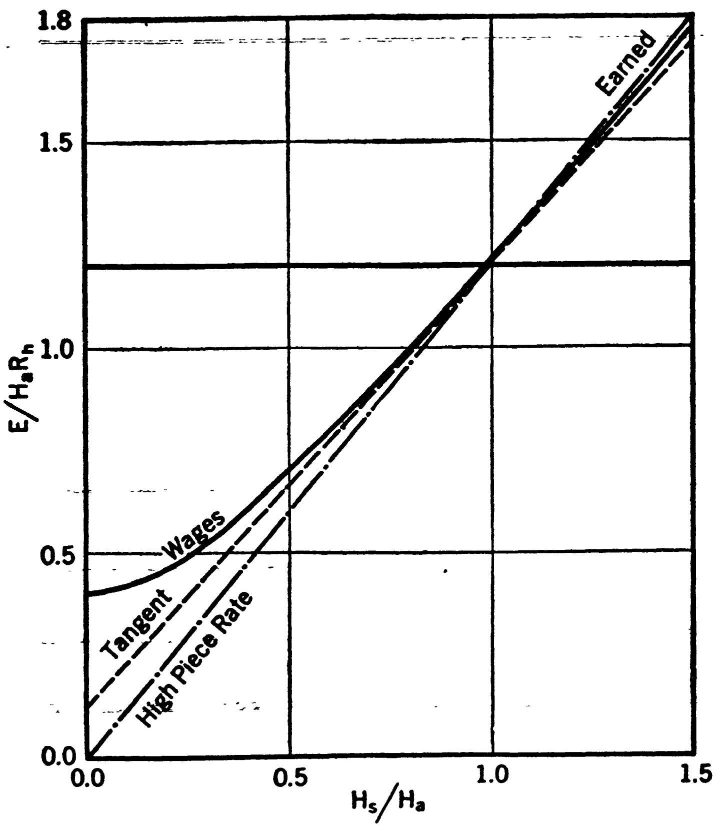

Figure 96. Hyperbolic Plan ($W = 1.20$, $B = .40$)

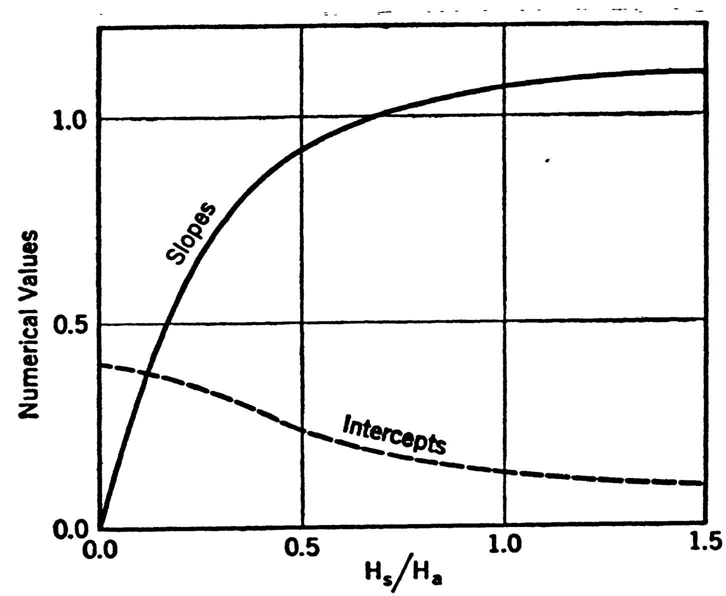

Figure 97. Analyzer Curves for Earning Curve of Figure 96

Coefficients for the Analyzer

Solid Curve = m Broken Curve = b

$E = H_a R_h + (m + b - 1) H_a R_h + m (H_s - H_a) R_h$
$E = (m + b) H_a R_h + m (H_s - H_a) R_h$
$E = m H_s R_h + b H_a R_h$

TABLE 76. COMPUTATIONS FOR HYPERBOLIC EARNINGS CURVE

Where $W = 1.20$ $B = .60$ $(W^2 - B^2) = (1.2 + .6)(1.2 - .6) = 1.08$ $B^2 = .36$

A	B	C	D	E	F	G	H	I	J
A	A²	C	B × C	E	D + E	$\sqrt{F}$	E ÷ G	G − H	I ÷ A
x	x^2	$(W^2 - B^2)$	$(W^2 - B^2)x^2$	B^2	$(W^2-B^2)x^2+B^2$	y	$b_i = \frac{B^2}{y}$	$\frac{y^2 - B^2}{y}$	$m_i = \frac{(W^2-B^2)x}{xy}$
.0	.00	1.08	.0000	.36	.3600	.6000	.6000	.0000	.0000
.1	.01	1.08	.0108	.36	.3708	.6089	.5912	.0177	.1770
.2	.04	1.08	.0432	.36	.4032	.6350	.5669	.0681	.3405
.3	.09	1.08	.0972	.36	.4572	.6764	.5322	.1444	.4813
.4	.16	1.08	.1728	.36	.5328	.7299	.4932	.2367	.5918
.5	.25	1.08	.2700	.36	.6300	.7937	.4536	.3401	.6802
.6	.36	1.08	.3888	.36	.7488	.8653	.4160	.4493	.7419
.7	.49	1.08	.5292	.36	.8892	.9428	.3827	.5601	.8001
.7698	.59	1.08	.6400	.36	1.0000	1.0000	.3600	.6400	.8314
.8	.64	1.08	.6912	.36	1.0512	1.0253	.3511	.6742	.8428
.9	.81	1.08	.8748	.36	1.2348	1.1112	.3239	.7873	.8748
1.0	1.00	1.08	1.0800	.36	1.4400	1.2000	.3000	.9000	.9000
1.1	1.21	1.08	1.3068	.36	1.6668	1.2910	.2789	1.0121	.9201
1.2	1.44	1.08	1.5552	.36	1.9152	1.3839	.2601	1.1238	.9365
1.3	1.69	1.08	1.8252	.36	1.1852	1.4782	.2435	1.2347	.9498
1.4	1.96	1.08	2.1168	.36	1.4768	1.5738	.2287	1.3451	.9608
1.5	2.25	1.08	2.4300	.36	1.7900	1.6703	.2155	1.4548	.9699

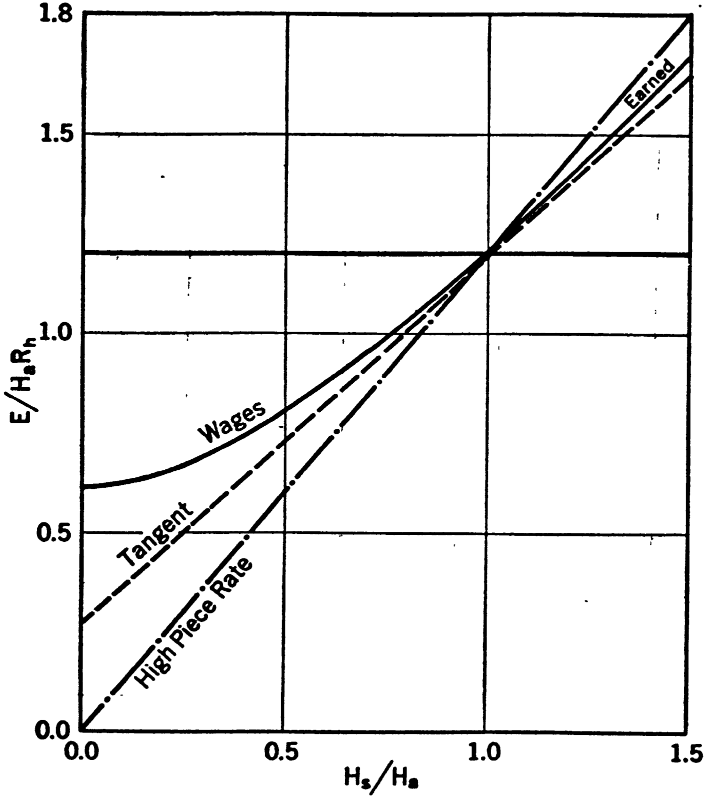

Figure 98. Hyperbolic Plan ($W = 1.20$, $B = .60$)

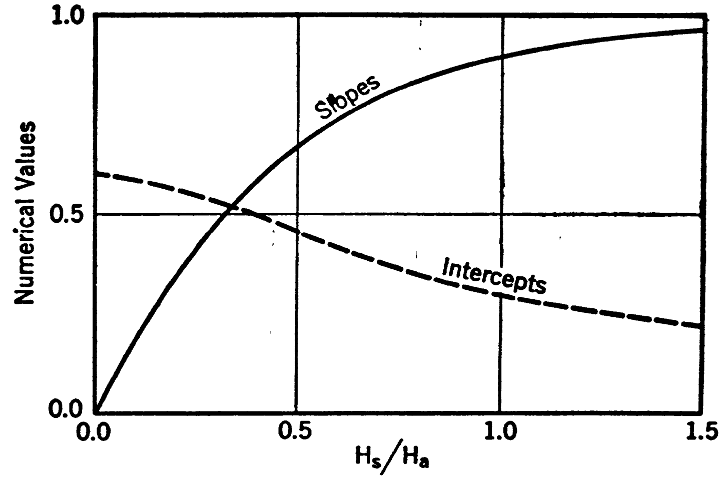

Figure 99. Analyzer Curves for Earning Curve of Figure 98

COEFFICIENTS FOR THE ANALYZER

Solid curve = m Broken curve = b

$$E = H_a R_h + (m + b - 1)\, H_a R_h + m\,(H_s - H_a)\, R_h$$
$$E = (m + b)\, H_a R_h + m\,(H_s - H_a)\, R_h$$
$$E = m\, H_s R_h + b\, H_a R_h$$

TABLE 77. COMPUTATIONS FOR HYPERBOLIC EARNINGS CURVE

Where $W = 1.20$ $B = .80$ $(W^2 - B^2) = (1.2 + .8)(1.2 - .8) = .80$ $B^2 = .64$

A	B	C	D	E	F	G	H	I	J
Assumed Argument	A²	Computed Constant	B × C	Computed Constant	D + E	√F	E ÷ G	G − H	I ÷ A
x	x^2	$(W^2 - B^2)$	$(W^2 - B^2)x^2$	B^2	$(W^2 - B^2)x^2 + B^2$	y	$b_t = \frac{B^2}{y}$	$\frac{y^2 - B^2}{y}$	$m_t = \frac{(W^2 - B^2)x^2}{xy}$
.0	.0	.80	.000	.64	.6400	.8000	.8000	.0000	.0000
.1	.01	.80	.008	.64	.648	.8050	.7950	.0100	.1000
.2	.04	.80	.032	.64	.672	.8198	.7807	.0391	.1955
.3	.09	.80	.072	.64	.712	.8438	.7585	.0883	.2943
.4	.16	.80	.128	.64	.768	.8764	.7303	.1461	.3653
.5	.25	.80	.200	.64	.840	.9165	.6983	.2182	.4364
.6	.36	.80	.288	.64	.928	.9633	.6644	.2989	.4982
.67	.45	.80	.360	.64	1.000	1.0000	.6400	.3600	.5373
.7	.49	.80	.392	.64	1.032	1.0159	.6300	.3859	.5513
.8	.64	.80	.512	.64	1.152	1.0733	.5963	.4770	.5963
.9	.81	.80	.648	.64	1.288	1.1349	.5639	.5710	.6344
1.0	1.00	.80	.800	.64	1.440	1.2000	.5333	.6667	.6667
1.1	1.21	.80	.968	.64	1.608	1.2681	.5047	.7634	.6940
1.2	1.44	.80	1.152	.64	1.792	1.3387	.4781	.8606	.7172
1.3	1.69	.80	1.352	.64	1.992	1.4114	.4535	.9579	.7368
1.4	1.96	.80	1.568	.64	2.208	1.4859	.4307	1.0552	.7537
1.5	2.25	.80	1.800	.64	2.440	1.5621	.4097	1.1524	.7616

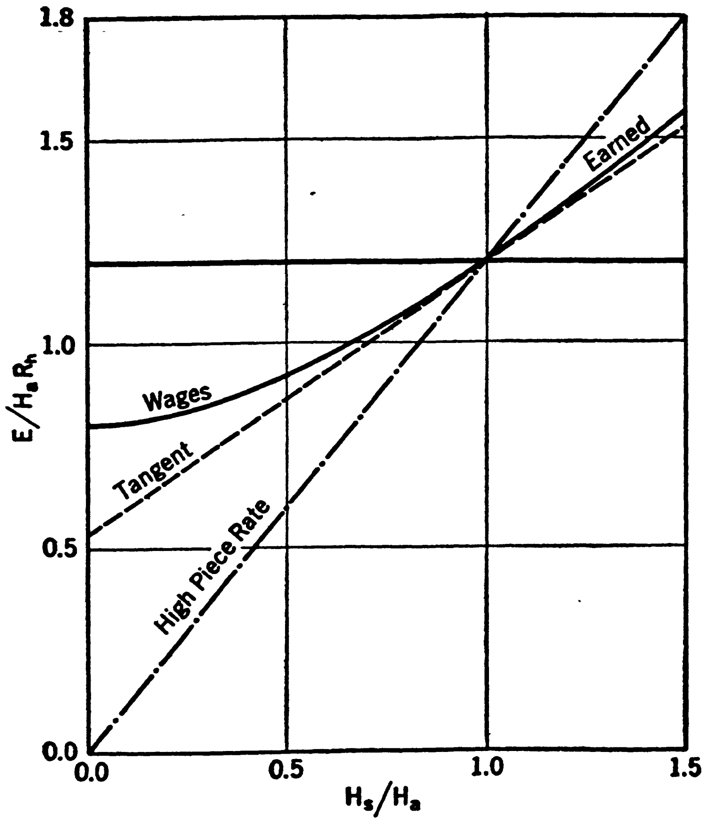

Figure 100. Hyperbolic Plan ($W = 1.20$, $B = .80$)

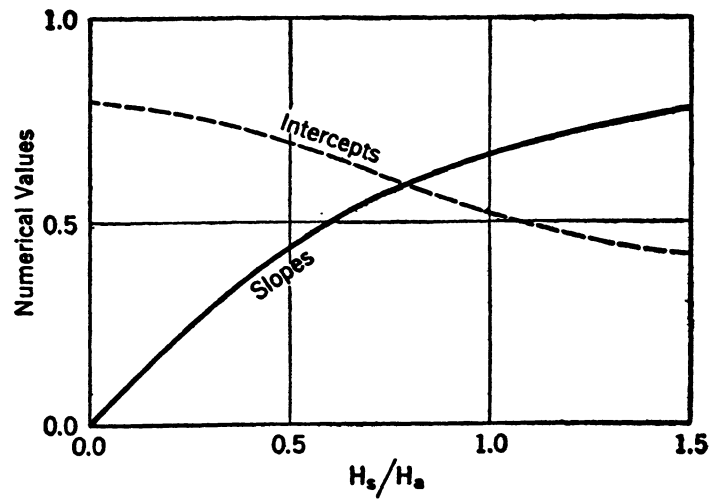

Figure 101. Analyzer Curves for Earning Curve of Figure 100

COEFFICIENTS FOR THE ANALYZER

Solid curve = m Broken curve = b

$$E = H_a R_h + (m + b - 1) H_a R_h + m (H_s - H_a) R_h$$
$$E = (m + b) H_a R_h + m (H_s - H_a) R_h$$
$$E = m \cdot H_s R_h + b \cdot H_a R_h$$

TABLE 78. COMPUTATIONS FOR HYPERBOLIC EARNINGS CURVE

Where $W = 1.20$ $B = 1.0$ $(W^2 - B^2) = (1.2 + 1.0)(1.2 - 1.0) = .44$ $B^2 = 1.0$

A	B	C	D	E	F	G	H	I	J
Assumed Argument	A^2	Computed Constant	$B \times C$	Computed Constant	$D + E$	$\sqrt{F}$	$E \div G$	$G - H$	$I \div A$
x	x^2	$(W^2 - B^2)$	$(W^2 - B^2)x^2$	B^2	$(W^2 - B^2)x^2 + B^2$	y	$b_t = \frac{B^2}{y}$	$\frac{y^2 - B^2}{y}$	$m_t = \frac{(W^2 - B^2)x^2}{xy}$
.0	.0	.44	.0000	1.0	1.0000	1.0000	1.0000	.0000	.0000
.1	.01	.44	.0044	1.0	1.0044	1.0022	.9978	.0044	.0440
.2	.04	.44	.0176	1.0	1.0176	1.0087	.9914	.0173	.0865
.3	.09	.44	.0396	1.0	1.0396	1.0196	.9808	.0388	.1293
.4	.16	.44	.0704	1.0	1.0704	1.0346	.9666	.0680	.1700
.5	.25	.44	.1100	1.0	1.1100	1.0536	.9491	.1045	.2090
.6	.36	.44	.1584	1.0	1.1584	1.0763	.9291	.1472	.2453
.7	.49	.44	.2156	1.0	1.2156	1.1025	.9070	.1955	.2793
.8	.64	.44	.2904	1.0	1.2904	1.1360	.8803	.2563	.3204
.9	.81	.44	.3564	1.0	1.3564	1.1647	8586	.3061	.3401
.0	1.00	.44	.4400	1.0	1.4400	1.2000	8333	.3667	.3667
1.1	1.21	.44	.5324	1.0	1.5324	1.2379	8066	.4313	.3921
1.2	1.44	.44	.6336	1.0	1.6336	1.2781	7824	.4957	.4131
1.3	1.69	44	.7436	1.0	1.7436	1.3203	.7528	.5673	.4364
1.4	1.96	44	.8624	1.0	1.8624	1.3647	.7328	.6319	.4514
1.5	2.25	44	.9900	1.0	1.9900	1.4107	.7089	.7018	.4679

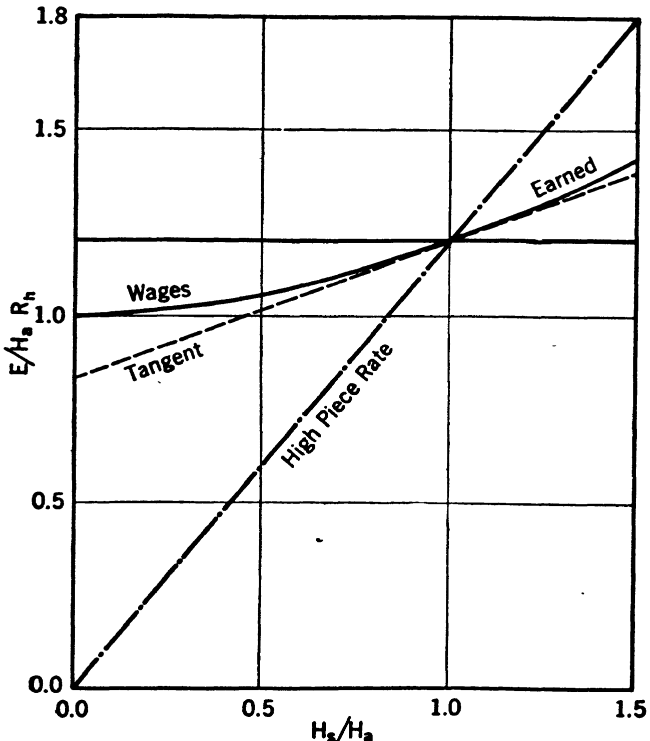

Figure 102. Hyperbolic Plan ($W = 1.20$, $B = 1.00$)

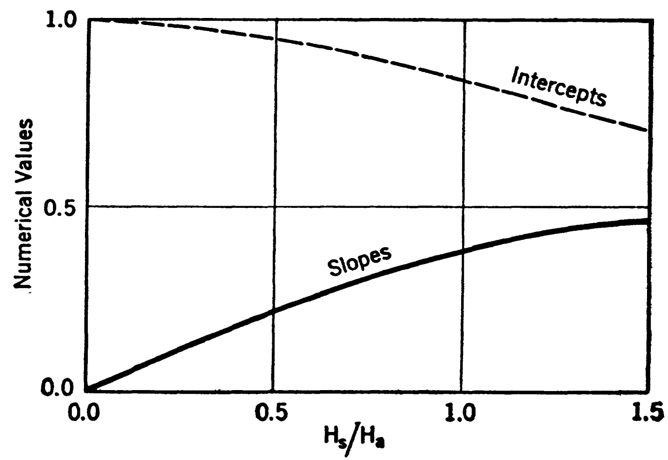

Figure 103. Analyzer Curves for Earning Curve of Figure 102

COEFFICIENTS FOR THE ANALYZER

Solid curve $= m$ Broken curve $= b$

$$E = H_a R_h + (m + b - 1) H_a R_h + m (H_s - H_a) R_h$$
$$E = (m + b) H_a R_h + m (H_s - H_a) R_h$$
$$E = m \cdot H_s R_h + b \cdot H_a R_h$$

Functions Used to Set Up Analyzers.—The hyperbolic function allows the computation of the constant K which when multiplied by x or H_s/H_a gives the hyperbolic sine. Since

$$K = \sqrt{\frac{W^2 B^2}{B^2}} = \sqrt{\frac{(W + B)}{B} \frac{(W - B)}{B}} \quad \text{assumed at (46)}$$

$$K^2 = \left(\frac{1.2 + 0.83}{0.83}\right) \left(\frac{1.2 - 0.83}{0.83}\right) = 1.0736$$

whence $$K = \sqrt{1.0736} = 1.0361 +$$

This is then entered in the appropriate column and the prescribed routine followed for the solution of y, m, and b. The columnar computations may be seen in Tables 79, 80, and 81. A tenth column (J) has been added to permit the addition of $m + b$ which is a factor arising as a coefficient in one of the standard forms of earnings-curve. Earnings are depicted in four particular forms first, although placed in the last column as a function of the formula, then in three ways as a function of the analyzer.

(a) $E = y\, H_a\, R_h$

(b) $E = H_a\, R_h + (m + b - 1)\, H_a\, R_h + m\, (H_s - H_a)\, R_h$

(c) $E = (m + b)\, H_a\, R_h + m\, (H_s - H_a)\, R_h$

(d) $E = m\, H_s\, R_h + b\, H_a\, R_h$

Final results are shown in Table 56 and Figure 78, Chapter 15.

TABLE 79. FUNCTIONAL COMPUTATIONS FOR HYPERBOLIC FORMULAS

Where $K^2 = \frac{(1.2)^2 - (.8333)^2}{(.83333)^2} = 1.0736$, whence $K = 1.036146707$ and $B = .833333333$

A	B	C	D	E	F	G	H	I	J
A	B	A × B	From Tables	E	D × E	E ÷ D	F − G	H ÷ A	G + I
$x = \frac{H_s}{H_a}$	$K = \sqrt{\frac{W^2 - B^2}{B^2}}$	$\sinh u = Kx$	$\cosh u$	$B = R_b$	$y = B \cosh u$	$b = \frac{B}{\cosh u}$	$y - b$	$m = \frac{y - b}{x}$	$m + b$
.0	1.03615	.00000	1.00000	.8333	.8333	.8333	.0000	.0000	.8333
.1	1.03615	.10361	1.00535	.8333	.8378	.8289	.0089	.0890	.9197
.2	1.03615	.20721	1.02124	.8333	.8510	.8160	.0350	.1750	.9910
.3	1.03615	.31084	1.04719	.8333	.8727	.7958	.0769	.2563	1.0421
.4	1.03615	.41446	1.08249	.8333	.9021	.7698	.1323	.3308	1.1006
.5	1.03615	.51807	1.12625	.8333	.9385	.7399	.1986	.3972	1.1371
.6	1.03615	.62169	1.17750	.8333	.9812	.7077	.2735	.4558	1.1635
.64	1.03615	.66333	1.20000	.8333	1.0000	.6944	.3056	.4774	1.1718
.66	1.03615	.68386	1.21147	.8333	1.0096	.6879	.3217	.4874	1.1753
.73	1.03615	.75639	1.25384	.8333	1.0449	.6646	.3803	.5209	1.1855
.80	1.03615	.82892	1.29888	.8333	1.0824	.6416	.4408	.5510	1.1926
.89	1.03615	.92217	1.36029	.8333	1.1336	.6126	.5210	.5854	1.1980
1.00	1.03615	1.03615	1.45000	.8333	1.2000	.5787	.6213	.6213	1.2000
1.14	1.03615	1.18121	1.54766	.8333	1.2897	.5384	.7513	.6590	1.1974
1.3333	1.03615	1.38153	1.70537	.8333	1.4211	.4887	.9324	.6993	1.1880
1.45	1.03615	1.50241	1.80478	.8333	1.5040	.4617	1.0423	.7188	1.1805
1.50	1.03615	1.55422	1.84814	.8333	1.5401	.4509	1.0892	.7261	1.1770

from which Table 56 and Figure 78 were made

TABLE 80. ARITHMETIC COMPUTATIONS FOR HYPERBOLIC FORMULAS

$B = .833$

A	B	C	D	E	F	G	H	I	J
A	A^2	C	B × C	E	D + E	$\sqrt{F}$	E ÷ G	G − H	I ÷ A
x	x^2	$(W^2 - B^2)$	$(W^2 - B^2)x^2$	B^2	$(W^2 - B^2)x^2 + B^2$	y	$b = \frac{B^2}{y}$	$\frac{y^2 - B^2}{y}$	$m = \frac{(W^2 - B^2)x^2}{xy}$
.0	.0000	.7455	.0000	.6944	.6944	.8333	.8333	.0000	.0000
.1	.0100	.7455	.0075	.6944	.7019	.8378	.8289	.0089	.0890
.2	.0400	.7455	.0298	.6944	.7242	.8510	.8160	.0350	.1750
.3	.0900	.7455	.0671	.6944	.7615	.8727	.7957	.0770	.2567
.4	.1600	.7455	.1193	.6944	.8137	.9021	.7698	.1323	.3308
.5	.2500	.7455	.1864	.6944	.8808	.9385	.7400	.1985	.3970
.6	.3600	.7455	.2684	.6944	.9628	.9812	.7078	.2734	.4557
.64	.4098	.7455	.3056	.6944	1.0000	1.0000	.6944	.3056	.4774
.66	.4356	.7455	.3247	.6944	1.0191	1.0095	.6879	.3216	.4873
.73	.5329	.7455	.3973	.6944	1.0917	1.0448	.6647	.3801	.5207
.80	.6400	.7455	.4771	.6944	1.1715	1.0824	.6416	.4408	.5510
.89	.7921	.7455	.5905	.6944	1.2849	1.1335	.6127	.5208	.5846
1.00	1.0000	.7455	.7455	.6944	1.4400	1.2000	.5787	.6213	.6213
1.14	1.2996	.7455	.9689	.6944	1.6633	1.2897	.5385	.7512	.6589
1.33	1.7689	.7455	1.3187	.6944	2.0131	1.4188	.4895	.9293	.6987
1.45	2.1025	.7455	1.5674	.6944	2.2618	1.5039	.4618	1.0421	.7187

from which Table 56 and Figure 78 were made

TABLE 81. ACCELERATING PREMIUM (HYPERBOLIC) DATA, 83⅓% MINIMUM

(Base Rate of Wages $3.84 per 8-hour day. Material $.12 per piece. Overhead $3.84 per man-day.)

A	B	C	D	E	F	G	H	I	J
Assumed Argument	24 × A	B ÷ 3	$8 \times \frac{A-1}{A}$	Computed Elsewhere	3.84 × E	F ÷ B	3.84 ÷ B	Given Constant	G + H + I
Ratio of Production to Standard	Pieces Made in 8 Hours	Standard Hours for Work Done	Hours Saved $H_s - H_a$	Earnings Ratio to Base Pay	Total Wages Earned per Day	Cost of Labor per Piece	Overhead Cost per Piece	Material Cost per Piece	Total Cost per Piece Produced
.0	.0	.0	∞	.8333	3.20	∞	∞	.12	∞
.1	2.40	.8	− 72.0	.8378	3.2172	1.3405	1.6000	.12	3.0605
.2	4.80	1.6	− 32.0	.8510	3.2678	.6808	.8000	.12	1.6008
.3	7.20	2.4	− 18.6	.8727	3.3512	.4654	.5333	.12	1.1187
.4	9.60	3.2	− 12.0	.9021	3.4641	.3608	.4000	.12	.8808
.5	12.00	4.0	− 8.0	.9385	3.6038	.3003	.3200	.12	.7403
.6	14.40	4.8	− 5.3	.9812	3.7678	.2617	.2667	.12	.6484
.64	15.36	5.12	− 4.4	1.0000	3.8400	.2500	.2500	.12	.6200
.66	15.84	5.28	− 4.1	1.0096	3.8769	.2448	.2424	.12	.6072
.73	17.52	5.64	− 3.3	1.0449	4.0124	.2290	.2192	.12	.5682
.80	19.20	6.40	− 2.0	1.0824	4.1564	.2165	.2000	.12	.5365
.89	21.36	7.12	− 1.0	1.1336	4.3530	.2039	.1798	.12	.5037
1.00	24.00	8.00	0.0	1.2000	4.6080	.1920	.1600	.12	.4720
1.14	27.36	9.12	1.0	1.2897	4.9524	.1809	.1404	.12	.4413
1.33	31.92	10.64	2.0	1.4211	5.4570	.1709	.1203	.12	.4112
1.45	34.80	11.60	2.5	1.5040	5.7754	.1658	.1103	.12	.3961
1.50	36.00	12.00	2.67	1.5401	5.9140	.1643	.1067	.12	.3910

from which Table 55, Chapter 15, was made

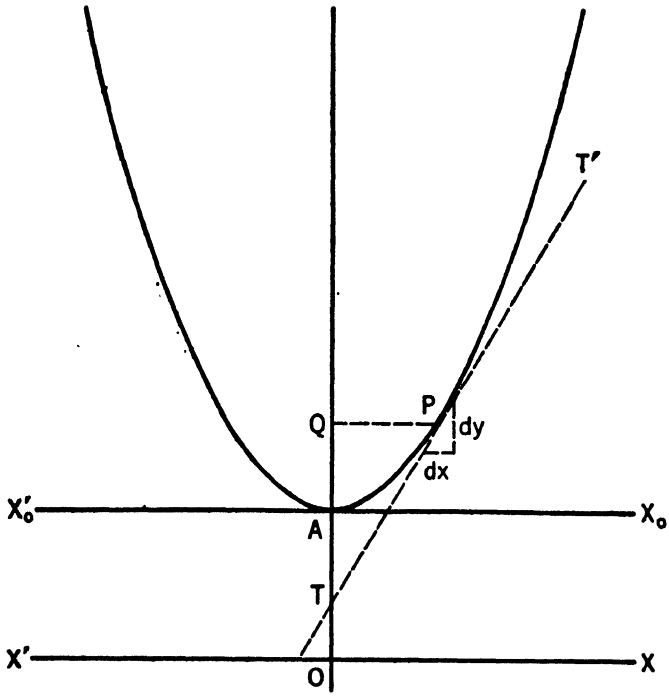

Figure 104. The Upright Parabola

Development of Parabolic Formulas.—In Figure 104,

$$\text{Slope of tangent } T P T^1 = T Q / P Q = m = \frac{dy}{dx}$$

$$\text{Intercept } O T = Q O - Q T = y - mx$$

$$\text{where } Q P = x, \; Q O = y, \text{ and } A O = B$$

The general equation of the vertical parabolas symmetric about the vertical axis and passing through the origin is $y = ax^n$ (2a)

and when the axis is moved from $x_o{}^1x_o$ to x^1x,

the intercept b is introduced. $y = ax^n + b$ (2)

Since the equation has three parametric constants, it can be passed through three arbitrary points or made to conform to three arbitrary conditions. The curve is to be passed through the same two points as was the hyperbola, while the third condition will be left until later. The points are: $x = 0$ when $y = B$, and $x = 1$ when $y = W$,

whence substitution gives $B = a(0)^n + b$, and $b = B$ (52)

while $W = a(1)^n + B$, whence $a = (W - B)$ (53)

substitution in (2) gives $y = (W - B)x^n + B$ (54)

as the general equation of the parabola passing through two predetermined points. The third condition is now to be applied by giving the curve a predetermined slope as it passes through the point $(x = 1)$, $(y = W)$. The slope of a curve is determined by substituting the coordinates of the point on the curve through which a tangent is to be drawn in the first derivative of the curve's equation. Thus by differentiating equation (54),

$$dy = d\,[(W - B)\,x^n + B] \tag{55}$$

$$\frac{dy}{dx} = n\,(W - B)\,x^{n-1} \tag{56}$$

whence since $x = 1$, then $\frac{dy}{dx} = n\,(W - B)$ (57)

and further since the slope of this tangent is such that it will pass through the origin and the high task point, that is $x = 0$ when $y = 0$, $x = 1$ when $y = W$ (58)

The slope of the tangent through the high task point (1.0, 1.2) becomes

$$\frac{y_2 - y_1}{x_2 - x_1} = m = \frac{W - 0}{1 - 0} \tag{59}$$

and $$\frac{dx}{dy} = m = W \tag{60}$$

whence $$\frac{dy}{dx} = m = W = n\,(W - B) \tag{61}$$

and $$n = \frac{W}{W - B} \tag{62}$$

which is the *evaluation of the exponent to make the curve pass through two predetermined points tangent to a fixed line through the more remote point.* Substitution of this value in equation (54) gives:

$$y = (W - B)\,x^{\frac{W}{W-B}} + B \tag{63}$$

as the *general equation of the parabolic curve.*

Since the tangent slope was found to be

$$m = n\,(W - B)\,x^{n-1} \qquad (56)$$

where $$n = \frac{W}{W - B} \qquad (62)$$

then $$m = Wx^{n-1} \qquad (63)$$

and $$mx = Wx^n \qquad (64)$$

but from (54), $$y = Wx^n - Bx^n + B \qquad (65)$$

and from (22), $$y = mx + b$$

whence equating (65) and (22) and substituting the value of mx from (64),

$$Wx^n - Bx^n + B = Wx^n + b \qquad (66)$$

$$\text{whence } b = B\,(1 - x^n) \qquad (67)$$

which is the value of the intercept of the tangent whence,

$$m = \frac{Wx^n}{x} \qquad (68)$$

$$b = B\,(1 - x^n) \qquad (69)$$

are the desired factors, which substituted in the equation of the tangent (22) give

$$y = Wx^n + B\,(1 - x^n) \qquad (70)$$

as the equation of the analyzer. The functional values of the parabolic curves may now be written as:

$$n = \frac{W}{W - B} \qquad (62)$$

$$y = Wx^n + B\,(1 - x^n) \qquad (65a)$$

$$y = (W - B)\,x^n + B \qquad (65b)$$

$$y = mx + b \qquad (22)$$

$$b = B\,(1 - x^n) \qquad (67)$$

$$m = \frac{Wx^n}{x} \qquad (68)$$

for their algebraic and arithmetic solution. However, there are times when it is necessary to determine the abscissa which corresponds to a given ordinate, such for instance, when the curve crosses

the basic wage line, and the ordinate becomes unity. This is easily accomplished by rearranging the second equation for y in the group immediately above and solving for x^n. This then takes the form

$$x^n = \frac{y - B}{W - B} \qquad (70a)$$

which makes for an easy solution. This formula should be compared with that for the hyperbola, in which the identical expression is multiplied by a second term in which the negative signs change to plus signs thus (70a):

$$x_p{}^n = \frac{y - B}{W - B} \text{ while } x_h{}^2 = \frac{y - B}{W - B} \cdot \frac{y + B}{W + B} \qquad (11b)$$

The solution of the parabola can be effected by several procedures in tabular arrangement, all of which are predicated on the determination of x to the nth power. Since n is not necessarily an integer, but may be any decimal number, resort must be had to logarithms to obtain the indicated power of the argument. This requires a total of five columns. The procedure which then follows depends on which of the two formulas

$$y = Wx^n + B\,(1 - x^n), \text{ or } y = (W - B)\,x^n + B \qquad (65b)$$

is used. The first form permits a shorter tabulation for the computations of the several desired elements, but does not permit of as simple a reversal of procedure for the computation of x when y is assumed. However, as demonstrated previously,

$$x^n = \frac{y - B}{W - B} \qquad (70a)$$

which permits a relatively simple solution for x^n where but a limited number of solutions are required and provide for the direct entry of the values of x^n in the column provided for such values (Table 82). From this point the computations can be carried backward to x by reversing the logarithmic computations or forward to m by following the same procedure provided therefore when the computations are made on assumed values of x.

TABLE 82. PARABOLIC ELEMENTS

Column	Manipulate Columns as Indicated	Values Represented in Columns	Description of Manipulation of Columnar Values—down with light face for y and **up with bold face for x.**	Reverse Solution for x
A	Assumed Argument	x	Assume all necessary or desired values of x and enter in orderly array in this column. **When solving for x take antilog of column B values from log tables**	Antilog B
B	Log A	$\log x$	Take log values of column A values from log tables and enter here. **When solving for x divide values in column D by constant of column C and enter here.**	D ÷ C
C	Computed Constant	$\frac{W}{W-B}$	Compute the power constant of the curve from its parametric constants and enter here.	Computed Constant
D	A × C	$n \log x$	Multiply values of columns B and C and enter here. **Enter values of log column E values here.**	Log E
E	AntilogD	x^n	Take antilog values of column D from log tables. **Compute value of x^n from $x^n = \frac{y-B}{W-B}$.**	Computed value of x^n from formula
F	1.0 − E	$1.0 - x^n$	Subtract the values of column E from unity and enter here. **Continue same computation when y is given and solution for x is wanted.**	1.0 − E
W	Parametric Constant of Curve	W	Enter the arithmetic ratio of the parametric constant of the curve (larger) here. Column may be omitted in actual work.	W
B	Parametric Constant of Curve	B	Enter the arithmetic ratio of the smaller parametric constant of the curve here. Column may be omitted in actual work.	B
G	W × E	$mx = Wx^n$	Multiply the values of column E by the larger of the two parametric constants of the curve and enter here.	Wx^n
H	B × F	$b = B(1 - x^n)$	Multiply the values of column F by the smaller of the two parametric constants of the curve and enter here.	b
I	G + H	$y = x^n + b$	Add the values of columns G and H and enter the sum here for the determined values of the ordinate.	Assumed value of ordinate y
J	G ÷ A	$m = \frac{Wx^n}{x}$	Divide the values of column G by those in column A for the slope of the analyzer and enter quotient here.	m

The necessary or desired values of the abscissa x are entered in the first of ten or twelve columns depending whether columns are omitted or provided for the two constants W and B. Thus in the tabular layout these columns will be provided, but they have been omitted in the actual computations. The logarithm of x, obtained from suitable tables, is entered in the second column. The third column provides the constant which is the power to which x must be raised. The values in columns 2 and 3 are multiplied together and entered in the fourth column, and in turn are used as entries from which to obtain the antilog values from the tables to post in the fifth column as x^n. These values are then deducted from unity and the difference, plus or minus, entered in the sixth column. Two columns are now provided for the constants (W and B), then a ninth column provides for the product of Wx^n and a tenth column for the intercept b. The sum of $Wx^n + b$ is entered as y in the eleventh column, and the quotient of $Wx^n \div x$ as m in the last column.

Translation Into Standard Incentive Symbols.—When the parabolic development is used,

$$\text{where } y = mx + b \tag{22}$$

$$\text{and } m = \frac{Wx^n}{x} \tag{64}$$

$$b = B\,(1 - x^n) \tag{69}$$

the first substitution is for m which gives

$$m = \frac{W\left(\dfrac{H_s}{H_a}\right)^n}{\dfrac{H_s}{H_a}} \tag{64a}$$

and reduces to

$$m = \frac{W\,H_s{}^{(n-1)}}{H_a{}^{(n-1)}} \tag{71}$$

substitution for b gives

$$b = B\left[1 - \left(\frac{H_s}{H_a}\right)^n\right] \tag{69a}$$

which reduces to
$$b = \frac{B\,(H_a^n - H_s^n)}{H_a^n} \tag{72}$$

substitution in
$$y = \frac{E}{H_a\,R_h} = mx + b \tag{22}$$

gives
$$E = H_a\,R_h\left[\frac{W\,H_s^n}{H_a^n} + \frac{(H_a^n - H_s^n)B}{H_a^n}\right] \tag{73}$$

whence
$$E = B\,H_a\,R_h + \frac{(W - B)\,H_s^n\,R_h}{H_a^{(n-1)}} \tag{74}$$

$$E = \frac{[B\,H_a^n + (W - B)\,H_s^n]\,R_h}{H_a^{(n-1)}} \tag{75}$$

Since
$$x^n = \frac{y - B}{W - B} \tag{70a}$$

substitution gives
$$\left(\frac{H_s}{H_a}\right)^n = \frac{\dfrac{E}{H_a\,R_h} - B}{W - B} \tag{70b}$$

whence
$$\left(\frac{H_s}{H_a}\right)^n = \frac{\dfrac{E - B\,(H_a\,R_h)}{H_a\,R_h}}{W-B} \tag{70c}$$

and this reduces to
$$H_s^n = \frac{\dfrac{E\,H_a^{(n-1)} - B\,H_a^n\,R_h}{R_h}}{W-B} \tag{76}$$

$$= \frac{\dfrac{E\,H_a^{(n-1)}}{R_h} - B\,H_a^n}{W-B} \tag{77}$$

However, as pointed out, the actual tabular computations can best be made by assuming the conventional symbols x and y, after which the computed values can be converted to the wage payment quantities by simple substitution. Such was the procedure followed in the examples of this study.

Four Parabolic Plans.—We may now set up standard tables and charts for as many plans as we choose. It will be sufficient for the present to design four such plans to meet as many requirements regarding minimum wage, that is, where $B = \$.40$, $B = \$.60$, $B = \$.80$, and $B = \$1.00$. If the base wage were $1.00 per hour these plans would provide starting points at $.40, $.60, $.80, and $1.00 per hour respectively. $W = \$1.20$ in all of these plans. Tables 83 to 86 and Figures 105 to 112 give the earning curves and (100, 120) tangents, high piece rate in these plans, together with analyzer curves for the slopes and intercepts of each earning curve.

TABLE 83. COMPUTATIONS FOR PARABOLIC EARNINGS CURVE

Where $W = 1.20$ and $B = .40$

A	B	C	D	E	F	G	H	I	J
Assumed Argument	Log A	Computed Constant	A × C	Antilog D	1.00 − E	$W \times$ E	$B \times$ F	G + H	G ÷ A
x	$\log x$	$n = \frac{W}{W-B}$	$n \log x$	x^n	$1.0 - x^n$	$mx = Wx^n$	$b = B(1-x^n)$	$y = Wx^n + b$	m
.0	−∞	1.5	−∞	.0000	1.0000	.0000	.4000	.4000	.0000
.1	9.00000	1.5	8.50000	.0316	.9684	.0379	.3874	.4253	.3790
.2	9.30103	1.5	8.95154	.0894	.9106	.1073	.3642	.4716	.5365
.3	9.47712	1.5	9.21568	.1643	.8357	.1972	.3343	.5315	.6573
.4	9.60206	1.5	9.40309	.2530	.7470	.3036	.2988	.6024	.7590
.5	9.69897	1.5	9.54846	.3536	.6464	.4243	.2586	.6829	.8486
.6	9.77815	1.5	9.66724	.4648	.5352	.5578	.2141	.7719	.9296
.7	9.84510	1.5	9.76765	.5865	.4135	.7038	.1654	.8692	1.0054
.8	9.90309	1.5	9.85464	.7155	.2845	.8586	.1138	.9724	1.0733
.891	9.95004	1.5	9.92506	.7500	.2500	.9000	.1000	1.0000	1.1010
.9	9.95424	1.5	9.93136	.8538	.1462	1.0248	.0585	1.0833	1.1387
1.0	.00000	1.5	.00000	1.0000	.0000	1.2000	.0000	1.2000	1.2000
1.1	.04139	1.5	.06209	1.1537	− .1537	1.3844	− .0615	1.3229	1.2585
1.2	.07918	1.5	.11877	1.3145	− .3145	1.5774	− .1258	1.4516	1.3145
1.3	.11394	1.5	.17091	1.4822	− .4822	1.7786	− .1929	1.5857	1.3682
1.4	.14613	1.5	.21920	1.6565	− .6565	1.9878	− .2626	1.7252	1.4199
1.5	.17609	1.5	.26413	1.8371	− .8371	2.2045	− .3348	1.8697	1.4697

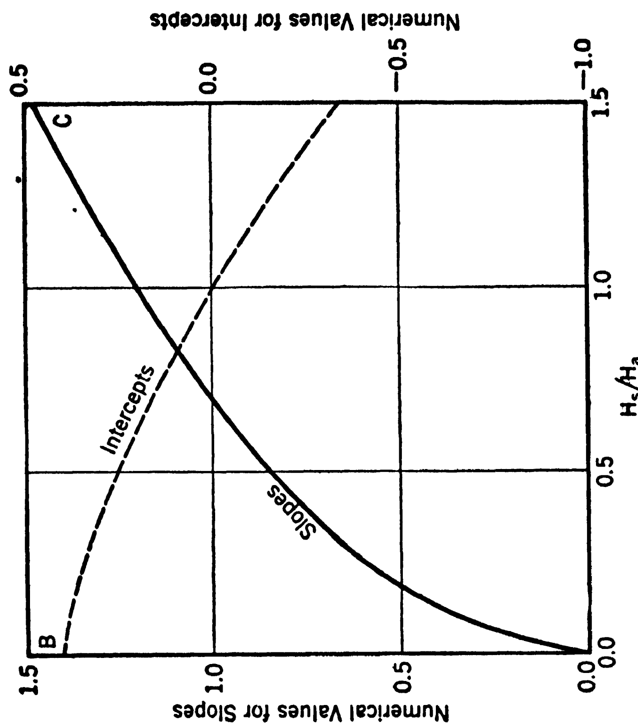

Figure 106. Analyzer Curves for Earning Curve of Figure 105

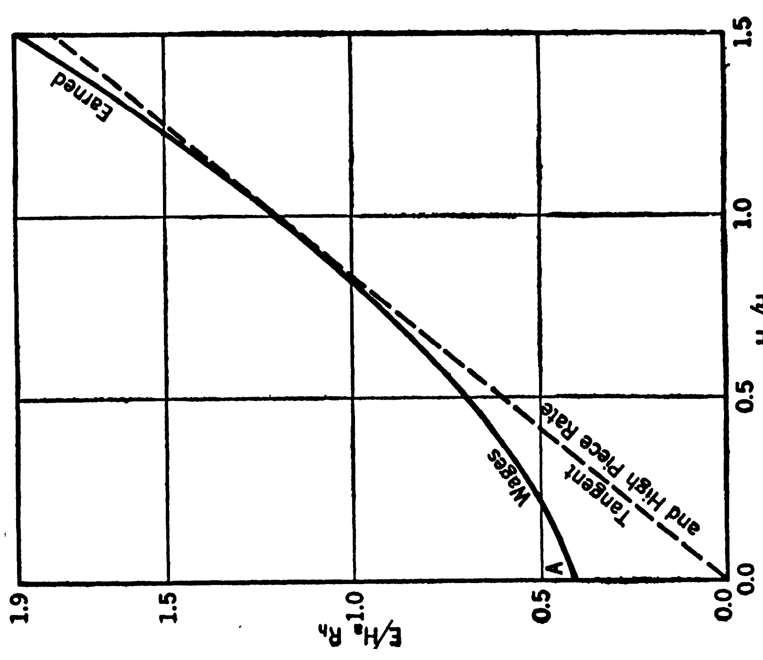

Figure 105. Parabolic Plan ($W = 1.20$, $B = .40$)

TABLE 84. COMPUTATIONS FOR PARABOLIC EARNINGS CURVE

Where $W = 1.20$ and $B = .60$

A	B	C	D	E	F	G	H	I	J
Assumed Argument	Log A	Computed Constant	A × C	Antilog D	1.00 − E	W × E	B × F	G + H	G ÷ A
x	$\log x$	$n = \frac{W}{W-B}$	$n \log x$	x^n	$1.0 - x^n$	$mx = Wx^n$	$b = B(1-x)$	$y = Wx^n + b$	m
.0	−∞	2.0	−∞	.0	1.00	.0000	.6000	.6000	.0000
.1	9.00000	2.0	8.00000	.01	.99	.0120	.5940	.6060	.1200
.2	9.30103	2.0	8.60206	.04	.96	.0480	.5730	.6210	.2400
.3	9.47712	2.0	8.95424	.09	.91	.1080	.5460	.6540	.3600
.4	9.60206	2.0	9.20412	.16	.84	.1920	.5040	.6960	.4800
.5	9.69897	2.0	9.39794	.25	.75	.3000	.4500	.7500	.6000
.6	9.77815	2.0	9.55630	.36	.64	.4320	.3840	.8160	.7200
.7	9.84510	2.0	9.69020	.49	.51	.5880	.3060	.8940	.8400
.8	9.90309	2.0	9.80618	.64	.36	.7680	.2160	.9840	.9600
.816	9.91173	2.0	9.82346	.67	.33	.8000	.2000	1.0000	.9978
.9	9.95424	2.0	9.90848	.81	.19	.9720	.1140	1.0860	1.0800
1.0	.00000	2.0	.00000	1.00	.00	1.2000	.0000	1.2000	1.2000
1.1	.04139	2.0	.08278	1.21	− .21	1.4520	− .1260	1.3260	1.3100
1.2	.07918	2.0	.15836	1.44	− .44	1.7280	− .2640	1.4640	1.4400
1.3	.11394	2.0	.22788	1.69	− .69	2.0280	− .4140	1.6140	1.5600
1.4	.14613	2.0	.29226	1.96	− .96	2.3520	− .5760	1.7760	1.6800
1.5	.17609	2.0	.35218	2.25	− 1.25	2.7000	− .7500	1.9500	1.8000

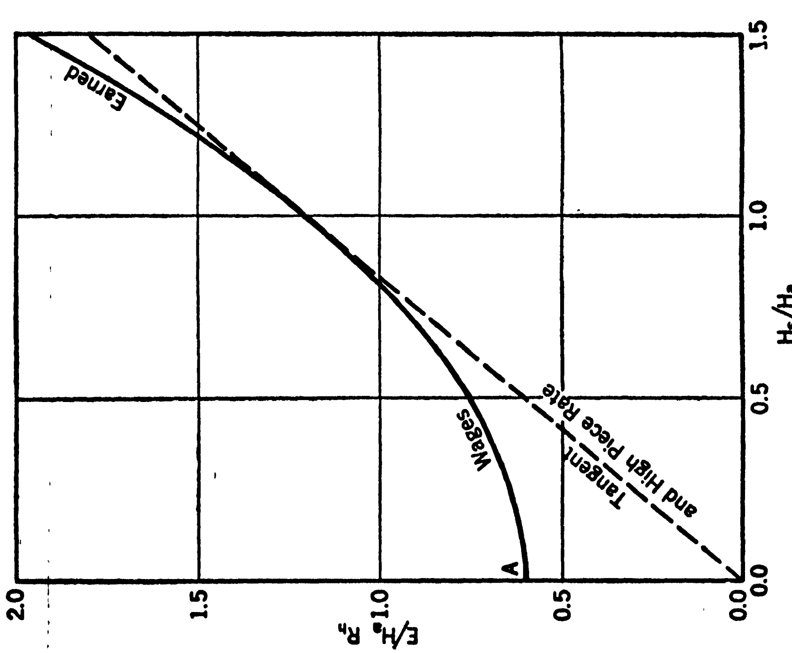

Figure 107. Parabolic Plan ($W = 1.20$, $B = .60$)

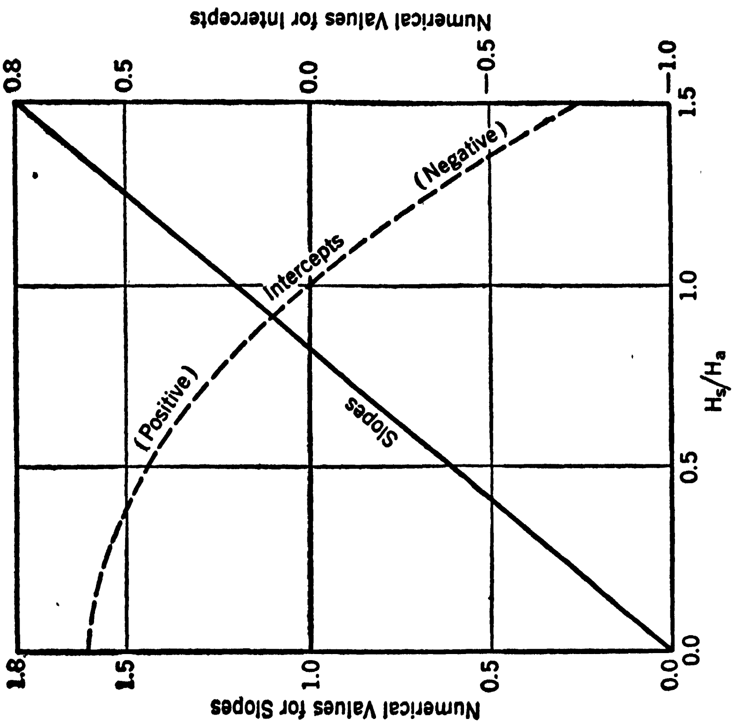

Figure 108. Analyzer Curves for Earning Curve of Figure 107

TABLE 85. COMPUTATIONS FOR PARABOLIC EARNINGS CURVE

Where $W = 1.20$ and $B = .80$

A	B	C	D	E	F	G	H	I	J
Assumed Argument	Log A	Computed Constant	A × C	Antilog D	1.00 − E	W × E	B × F	G + H	G ÷ A
x	log x	$n = \frac{W}{W-B}$	n log x	x^n	$1.00 - x^n$	$mx = Wx^n$	$b = B(1 - x^n)$	$y = Wx^n + b$	m
.0	−∞	3.0	−∞	.000	1.000	.0000	.8000	.8000	.0000
.1	9.00000	3.0	7.00000	.001	.999	.0012	.7992	.8004	.0120
.2	9.30103	3.0	7.90309	.008	.992	.0096	.7936	.8032	.0480
.3	9.47712	3.0	8.43136	.027	.973	.0324	.7784	.8108	.1080
.4	9.60206	3.0	8.80618	.064	.936	.0768	.7488	.8256	.1920
.5	9.69897	3.0	9.09691	.125	.875	.1500	.7000	.8500	.3000
.6	9.77815	3.0	9.33445	.216	.784	.2592	.6272	.8864	.4320
.7	9.84510	3.0	9.53530	.343	.657	.4116	.5256	.9372	.5737
.794	9.89966	3.0	9.69898	.500	.500	.6000	.4000	1.0000	.7559
.8	9.90309	3.0	9.70927	.512	.488	.6144	.3904	1.0048	.7680
.9	9.95424	3.0	9.86272	.729	.271	.8748	.2168	1.0916	.9720
1.0	.00000	3.0	.00000	1.000	.000	1.2000	.0000	1.2000	1.2000
1.1	.04139	3.0	.12417	1.331	− .331	1.5972	− .2648	1.3324	1.4520
1.2	.07918	3.0	.23754	1.728	− .728	2.0736	− .5824	1.4912	1.7280
1.3	.11394	3.0	.34182	2.197	− 1.197	2.6364	− 9576	1.6788	2.0280
1.4	.14613	3.0	.43839	2.744	− 1.744	3.2928	− 1.3952	1.8976	2.3520
1.5	.17609	3.0	.52827	3.375	− 2.375	4.0500	− 1.9000	2.1500	2.7000

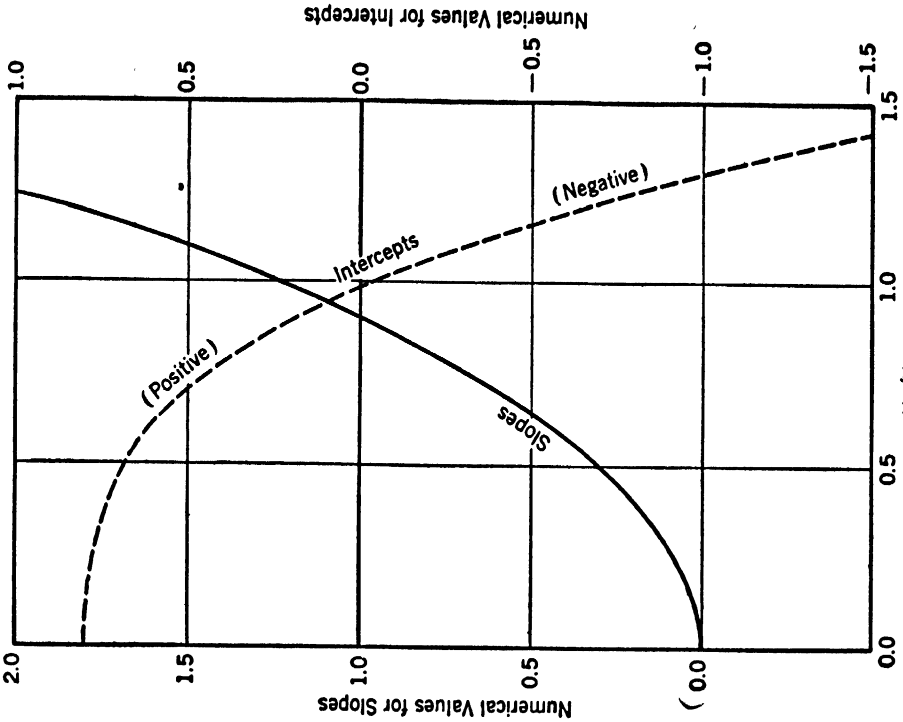

Figure 110. Analyzer Curves for Earning Curve of Figure 109

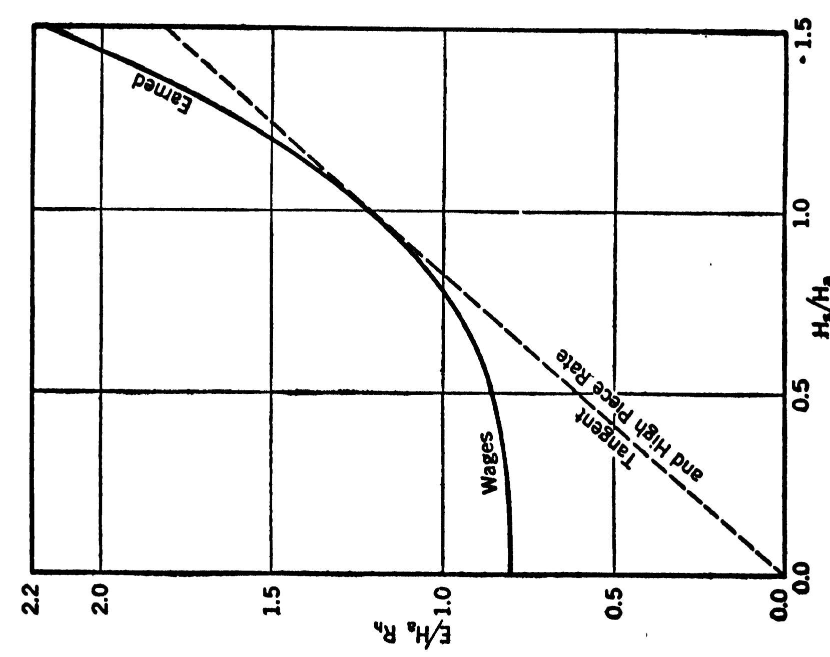

Figure 109. Parabolic Plan ($W = 1.20$, $B = .80$)

TABLE 86. COMPUTATIONS FOR PARABOLIC EARNINGS CURVE
Where $W = 1.20$ and $B = 1.00$

A	B	C	D	E	F	G	H	I	J
Assumed Argument	Log A	Computed Constant	A × C	Antilog D	1.00 − E	W × E	B × F	G + H	G ÷ A
x	$\log x$	$n = \frac{W}{W-B}$	$n \log x$	x^n	$1.00 - x^n$	$mx = Wx^n$	$b = B\ (1-x)$	$y = Wx^n + b$	m
.0		6.0							
.0	−∞	6.0	−∞	.0000	1.0000	.0000	1.0000	1.0000	.0000
.1	9.00000	6.0	4.00000	.0000 +	1.0000	.0000	1.0000	1.0000	.0000 +
.2	9.30103	6.0	5.80618	.0001	.9999	.0001	.9999	1.0000	.0005
.3	9.47712	6.0	6.86272	.0007	.9993	.0008	.9993	1.0001	.0023
.4	9.60206	6.0	7.61236	.0041	.9959	.0049	.9959	1.0008	.0103
.5	9.69897	6.0	8.19382	.0156	.9844	.0188	.9844	1.0032	.0312
.6	9.77815	6.0	8.66890	.0429	.9571	.0515	.9571	1.0086	.0858
.7	9.84510	6.0	9.07060	.1177	.8823	.1412	.8823	1.0235	.2017
.8	9.90309	6.0	9.41854	.2621	.7379	.3143	.7379	1.0522	.3929
.9	9.95424	6.0	9.72472	.5314	.4686	.6377	.4686	1.1263	.7086
1.0	.00000	6.0	.00000	1.0000	.0000	1.2000	.0000	1.2000	1.2000
1.1	.04139	6.0	.24834	1.7716	− .7716	2.1259	− .7716	1.3543	1.9326
1.2	.07918	6.0	.47472	2.9860	− 1.9860	3.5832	− 1.9860	1.5972	2.9860
1.3	.11394	6.0	.68364	4.8268	− 3.8268	5.7922	− 3.8268	1.9654	4.1605
1.4	.14613	6.0	.87678	7.5295	− 6.5295	9.0354	− 6.5295	2.5059	6.4539
1.5	.17609	6.0	1.05654	11.3916	−10.3916	13.6699	−10.3916	3.2783	9.1133

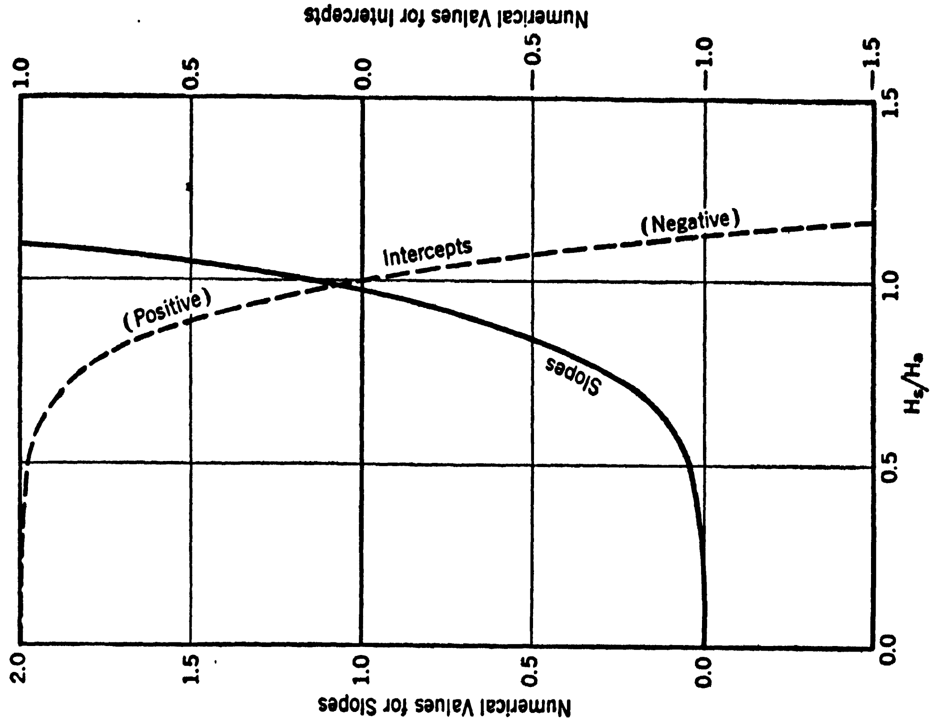

Figure 112. Analyzer Curves for Earning Curve of Figure 111

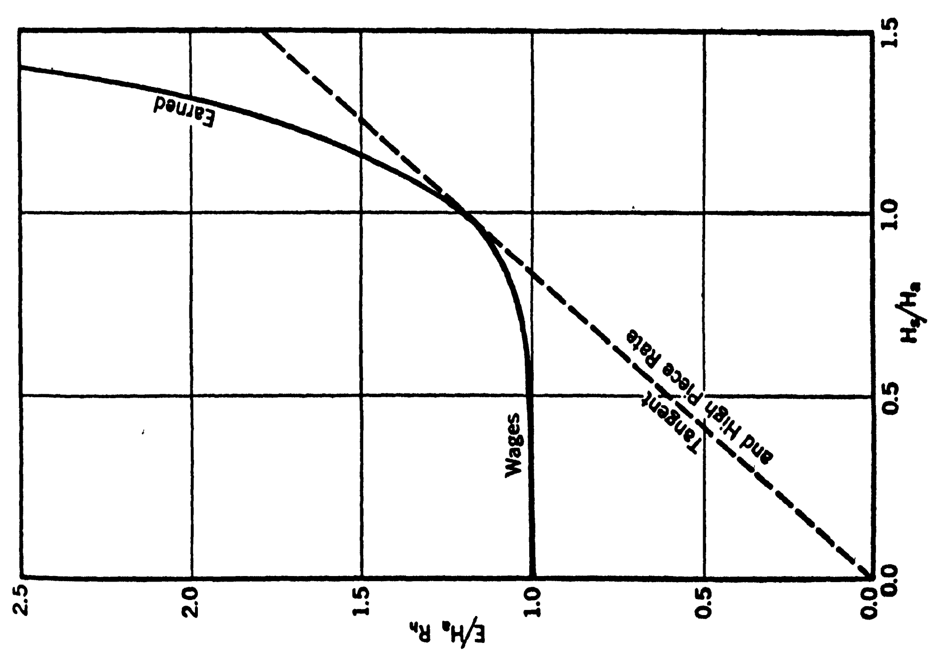

Figure 111. Parabolic Plan ($W = 1.20$, $B = 1.00$)

Table 87. Functional Computations for Parabolic Formulas

Where $W = 1.2$ $B = .83\frac{1}{3}$ $n = \frac{W}{W - B} = 3\frac{3}{11}$

A	B	C	D	E	F	G	H	I	J
Assumed Argument	Log A	Computed Constant	B × C	AntilogD	1.0 − E	W × E	B × F	G + H	G ÷ A
x	$\log x$	$n = \frac{W}{W - B}$	$n \log x$	x^n	$1 - x^n$	$Wx^n = mx$	$b = B(1 - x^n)$	$y = Wx^n + b$	m
.0		3.2727		.0000	1.0000	.0000	.8333	.8333	.0000
.1	9.00000	3.2727	6.72727	.0005	.9995	.0006	.8329	.8335	.0060
.2	9.30103	3.2727	7.71246	.0052	.9948	.0062	.8290	.8352	.0310
.3	9.47712	3.2727	8.28876	.0194	.9806	.0233	.8172	.8405	.0777
.4	9.60206	3.2727	8.69654	.0497	.9503	.0596	.7919	.8515	.1490
.5	9.69897	3.2727	9.01481	.1035	.8965	.1242	.7461	.8703	.2484
.6	9.77815	3.2727	9.27395	.1879	.8121	.2255	.6757	.9012	.3758
.66	9.81954	3.2727	9.40941	.2567	.7433	.3080	.6194	.9274	.4661
.73	9.86332	3.2727	9.55269	.3570	.6430	.4284	.5358	.9642	.5868
.79	9.89535	3.2727	9.65753	.4545	.5454	.5455	.4545	1.0000	.6904
.80	9.90309	3.2727	9.68284	.4818	.5182	.5782	.4318	1.0106	.7228
.89	9.94939	3.2727	9.83437	.6829	.3171	.8195	.2643	1.0838	.9208
1.00	.00000	3.2727	.00000	1.0000	.0000	1.2000	.0000	1.2000	1.2000
1.14	.05690	3.2727	.18622	1.5354	− .5354	1.8425	− .4462	1.3963	1.6162
1.33	.12385	3.2727	.40533	2.5429	− 1.5429	3.0515	− 1.2858	1.7657	2.2944
1.45	.16137	3.2727	.52812	3.3738	− 2.3738	4.0486	− 1.9782	2.0704	2.7921
1.50	.17609	3.2727	.57629	3.7695	− 2.7695	4.5234	− 2.3079	2.2155	3.0156

from which Table 58 and Figure 81 were made.

TABLE 88. ARITHMETIC COMPUTATIONS FOR PARABOLIC FORMULAS, 83⅓% MINIMUM

Base Rate of Wages $3.84 per 8 hour day. Material $0.12 per Piece Overhead $3.84 per Day per Man

A	B	C	D	E	F	G	H	I	J
Assumed Argument	24 × A	B ÷ 3	$8 \times \frac{A-1}{A}$	Computed Elsewhere	3.84 × E	F ÷ B	3.84 ÷ B	Given Constant	G + H + I
Ratio of Production to Standard	Pieces Produced in 8 Hours	Standard Hours for Work Done	Hours Saved Per 8-hr. Task $H_s - H_a$	Earnings Ratio to Base Pay	Total Wages Earned per 8-hr. Day	Cost of Labor per Piece	Overhead Cost per Piece	Material Cost per Piece	Total Cost per Piece Produced
.0	.0	.0	− ∞	.8333	3.20	∞	∞	.12	∞
.1	2.40	.8	− 72.0	.8335	3.2006	1.3336	1.6000	.12	3.0536
.2	4.80	1.6	− 32.0	.8352	3.2072	.6682	.8000	.12	1.5882
.3	7.20	2.4	− 18.6	.8405	3.2275	.4483	.5333	.12	1.1016
.4	9.60	3.2	− 12.0	.8515	3.2698	.3406	.4000	.12	.8606
.5	12.00	4.0	− 8.0	.8703	3.3420	.2785	.3200	.12	.7185
.6	14.40	4.8	− 5.3	.9012	3.4606	.2403	.2667	.12	.6270
.66	15.84	5.28	− 4.1	.9274	3.5612	.2248	.2424	.12	.5872
.73	17.52	5.84	− 3.0	.9642	3.7025	.2113	.2192	.12	.5405
.79	18.96	6.32	− 2.1	1.0000	3.8400	.2025	.2025	.12	.5250
.80	19.20	6.40	− 2.0	1.0100	3.8784	.2020	.2000	.12	.5220
.89	21.36	7.12	− 1.0	1.0838	4.1618	.1948	.1798	.12	.4946
1.00	24.00	8.00	0.0	1.2000	4.6080	.1920	.1600	.12	.4720
1.14	27.36	9.12	1.0	1.3963	5.3618	.1960	.1404	.12	.4564
1.33	31.92	10.64	2.0	1.7657	6.7803	.2124	.1203	.12	.4527
1.45	34.80	11.60	2.5	2.0704	7.9503	.2285	.1103	.12	.4588
1.50	36.00	12.00	2.6	2.2155	8.5075	.2363	.1067	.12	.4630

from which Table 57 and Figure 80 were made.

APPENDIX C

LIST OF COMPANIES FROM WHICH ILLUSTRATIONS AND EXAMPLES HAVE BEEN DRAWN[1]

Abbott Laboratories, The
Acme Wire Co.
Allen, S. L., & Co., Inc.
American Rolling Mills
Atlantic Refining Co., The
Atlas Underwear Co., The
Barber Asphalt Paving Co.
Brown Hoisting Machinery Co.
Bucyrus-Erie Co.
Bullard Machine Tool Co., The
Carter Ink Co., The
Cheney Bros.
Chicago Bridge and Iron Works
Chicago Flexible Shaft Co.
Chile Exploration Co.
Chrysler Motor Corporation
Continental Mills, Inc.
Continental Motors Corporation
Davison Paxton Co.
Deere & Co.
Delaware & Hudson Co., The
Dennison Manufacturing Co.
Dixon Crucible Co., Joseph
Du Pont de Nemours, E. I. & Co.
Dutchess Manufacturing Co.
Eastman Kodak Co.
Edison Electric Appliance Co., Inc.
Essex Rubber Co.
Gair Co., The Robert
General Electric Co.
General Iron Works Co., The
General Motors
Gilbert & Barker Manufacturing Co.
Gillette Safety Razor Co.
Hall Scott Motor Car Co.
Harder Manufacturing Co.
Holeproof Hosiery Co.
Hood Rubber Co.
Hoover Co., The
Horne Co., Joseph
Johnson & Johnson
Latham Machinery Co.
Leeds & Northrup Co.
Lilly & Co., Eli
Lycoming Manufacturing Co.
Metropolitan Life Insurance Co.
Mohawk Carpet Mills, Inc.
Newport News Shipbuilding & Drydock Corporation
Ohio Electric & Controller Co., The
Olds Motor Works
Pacific Mills
Packard Motor Car Co.
Pennsylvania Co.
Philadelphia Electric Co.
Portland Gas & Coke Co.
Priestman Foundries
Proctor & Schwartz, Inc.
Ralston Purina Co., Inc.
Real Silk Hosiery Mills
Revere Copper & Brass Co.
Rhoads, J. E. & Sons
Rowan & Co., David
Sayles Finishing Plants, Inc.
Sinclair, T. M. & Co., Ltd.
Steinway & Son
Stern & Sons, Joseph
Sullivan Machine Co.
Taylor, Wm., Son & Co.
U. S. Steel Corp.
Van Dorn Iron Works Co.
Veeder Root (Inc.)
Walworth Co.
Western Electric Co.
Westinghouse Air Brake Co.
Westinghouse Electric & Manufacturing Co.
White Sewing Machine Co.
Wilson & Co.
Wright Aeronautical Corp.

[1] Aid has also come from other companies which preferred to remain unnamed, all answering by means of the questionnaire, Appendix D.

APPENDIX D

Specimen Questionnaire

Questions *Wage plan under question*	Answers *Piece Rate, with guaranteed minimum daily earnings*
1. Is your application exactly like the usual one?	Yes.
2. If modified, please give points of difference.	——
3. About how many employees on this plan?	1,860 Men. 131 Women. (Avg. Yr.)
4. How long has it been in operation?	Approximately 50 years.
5. What are its	
(a) benefits?	1. Operator is paid in proportion to work accomplished. 2. Labor cost per piece cannot increase. 3. Simplest of incentive plans.
(b) shortcomings?	1. When an operator who ordinarily works on a piece work basis is asked to do work on a day work basis, such as repairing machines, etc. there is a possibility of the operator claiming more day work hours than were actually worked.
6. Did it replace any other plan?	No.
7. What was wrong with that?	——
8. How many clerks required for	
(a) Factory operation of plan?	12 Clerks.
(b) Office operation of plan?	4 Comptometer checkers.
9. Was the plan based on careful job methods and time standards?	The Time Study Department was established in March, 1924, and rates set since that time are based upon careful time standards. At the present time about 50% of our operations are worked on time studied piece prices.
10. Is the plan accompanied:	
(a) By individual production records?	Yes.
(b) By periodic adjustment of man rates? How often?	No. According to our wage agreement, dated May 1, 1920, no change can be made in a piece price established by time study so long as the conditions under which the piece price was established continue unchanged, such as the same machines, same tooling, same methods of handling, same material, same operations, etc., in fact, where no improvements or eliminations have been made.
(c) By any plan of promotion or other non-financial incentives?	None.
11. About what is the range of effectiveness for some typical operation?	
(a) Individual efficiency relative to task	All piece rates are set with the idea that the average workman with fair effort should produce his work in the standard or task time. An excellent worker can produce the same work in 15% to 25% less than this standard or task time.
(b) Individual earning	Same.
12. Total on payroll in plant?	3,659 Employees (not including salary employees). (Avg. yr.)

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